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Compressed Air Magazine

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CRIPPLE CREEK, COLO., IN 1908

YOUNG STUDIO PHOTO

CONTROL OF TEMPERATURES IN BENDING FURNACE.
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ON THE COVER

OUR cover picture shows Colorado's most famous gold camp, Cripple Creek, as it appeared 32 years ago when more than 10,000 persons lived there. At least two-thirds of the buildings were torn down during the World-War period and their materials sold. The Carlton Drainage Tunnel, described in this issue, promises to restore some of Cripple Creek's former prosperity, although it is doubtful if the town will ever be rebuilt to its 1908 proportions.

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IN THIS ISSUE

THE outlook now is that Cripple Creek will observe its fiftieth anniversary next year by putting the Carlton Drainage Tunnel into operation. The completion of that bore will mark a high point in the latter-day history of the camp. The total official gold production of Cripple Creek including 1939 is $386,866,758; but the actual output, considering stolen ore, is probably near $450,000,000. It is well known that the field is far from exhausted; and the camp looks forward to many more years of existence. Our leading article explains the object of the 6-mile tunnel and describes the methods by which it is being pushed forward faster than a hole was ever before punched through rock.

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GAS is used by almost every urban householder and has hundreds of industrial applications. The manufacture of this utility has undergone many changes and refinements during the past half-century. Each one has provided a better product at a lower cost. Operations at The Portland (Maine) Gas Light Company, exemplifying modern practice, are described by the assistant manager of the organization.

•

MANY persons have deplored the building of power dams on the Columbia River in the belief that they would cripple the salmon industry. We are assured, however, that there is no cause for alarm on this score. In fact, as is pointed out in our third article, the Government is taking ample steps to provide new homes and spawning waters for the fish that cannot pass Grand Coulee Dam. The operations entailed driving a pressure tunnel through rock to obtain water of the desired coldness.

•

MOVING heavy machinery isn't much of a chore in most parts of the United States, but it is often a herculean task a few miles south of the border. Details of one such transportation job are described and pictured in an article by C. R. King.

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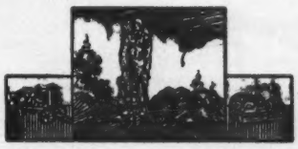

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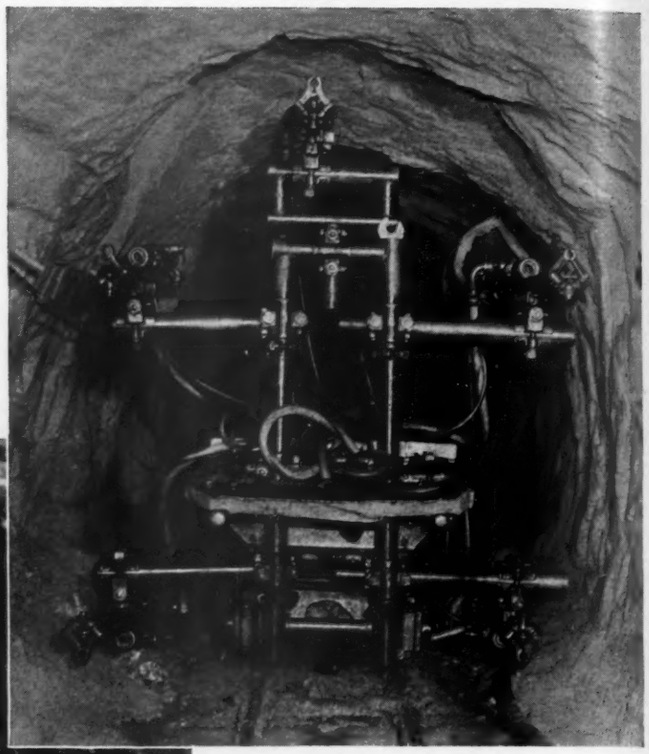
Carlton Drainage Tunnel to Give Cripple Creek New Life

C. H. Vivian

Photos, Thomas J. Barbre.



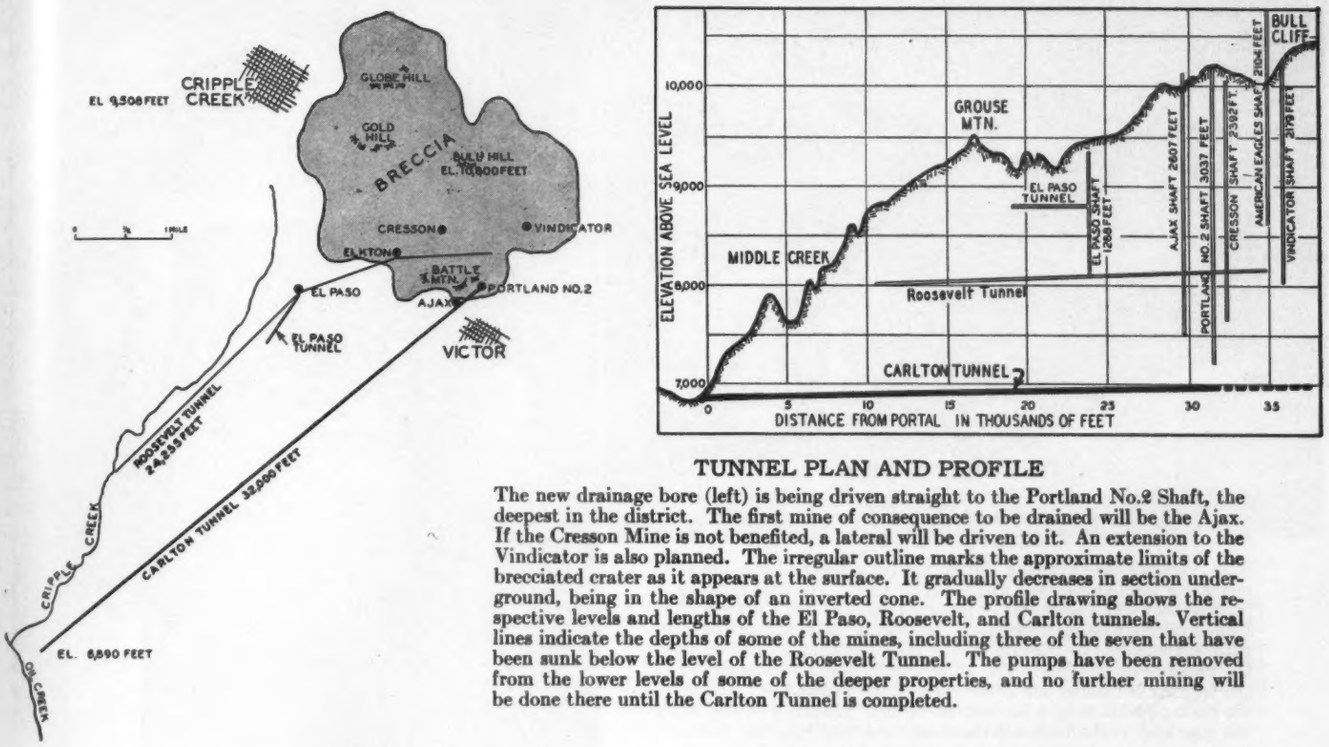
THE DRILL CARRIAGE

The upper picture shows the front end of the 5-ton drill carriage, with the five DA-35 drifters in position for drilling. The carriage has sufficient solidity without jacking up the columns or arms or blocking them to the tunnel sides. Just above is a view from the back of the carriage showing three of the drills in action. During April, an average of 7.13 rounds was drilled daily. Including the time spent in moving the carriage to and from the face, about 4⅛ hours of each shift are ordinarily spent in drilling and 3¾ hours in mucking.

UNUSUALLY fast progress is being made in driving the Carlton Tunnel, a drainage gallery designed to unwater the deeper mines in the world-famous gold camp of Cripple Creek, Colo. In fact, the face is being advanced so rapidly that revised estimates place the time required to complete the 32,000-foot bore at two years instead of slightly more than four. During the 31 consecutive days beginning on March 10 and ending on April 9, an advance of 1,879 feet was made, working at one heading. This surpasses by 16 feet the progress registered by forces of the Walsh Construction Company in one of the Delaware Aqueduct headings earlier in the year. During the week starting on March 31, the Carlton Tunnel was pushed ahead 488 feet. The best performance for one day was 74 feet, on April 6, and towards this total one crew contributed 27 feet of advance in an 8-hour shift. It is the belief of John R. Austin, superintendent of the work, that these marks have never before been equaled in a hard-rock tunnel. Another notable achievement that he thinks is a record was the driving of 2 miles of tunnel in 209 working days.

The Carlton Tunnel is the third drainage bore to be driven since Cripple Creek started producing telluride gold and silver ores in 1891. For some time after mining began, no water was encountered, and it was believed that Cripple Creek was to be a "dry" camp. Credence was lent to the theory by the fact that the location was nearly 10,000 feet above sea level, with considerable lower-lying terrain close by to which ground water could gravitate. However, as subsequent geological examinations disclosed, the mineralized zone is the denuded crater of an extinct volcano. At the surface it constitutes an irregular area roughly 4x3 miles in size. The prevailing rock is a breccia, characterized by angular fragments cemented together. It evidently was formed by recurring eruptions of lava each of which broke up partly solidified rock crusts from previous flows and rejoined them. This plug was intruded through a compact granite, locally termed Pikes Peak Granite, which now surrounds it. Secondary volcanic activity continued for some time after large-scale eruptions ceased, with the result that dikes, flats, and irregularly shaped masses of basic rocks such as phonolite and latite were forced upward through the breccia and the adjoining granite.

All this internal churning broke up the crater rock to a considerable degree and



TUNNEL PLAN AND PROFILE

The new drainage bore (left) is being driven straight to the Portland No.2 Shaft, the deepest in the district. The first mine of consequence to be drained will be the Ajax. If the Cresson Mine is not benefited, a lateral will be driven to it. An extension to the Vindicator is also planned. The irregular outline marks the approximate limits of the brecciated crater as it appears at the surface. It gradually decreases in section underground, being in the shape of an inverted cone. The profile drawing shows the respective levels and lengths of the El Paso, Roosevelt, and Carlton tunnels. Vertical lines indicate the depths of some of the mines, including three of the seven that have been sunk below the level of the Roosevelt Tunnel. The pumps have been removed from the lower levels of some of the deeper properties, and no further mining will be done there until the Carlton Tunnel is completed.

left it more porous than the granite that envelops it. In a measure, it represents a gigantic sponge that has soaked up ground water for countless ages and occupies the neck, so to speak, of a granite bottle the sides of which are relatively impervious. The only way to drain out some of the accumulated water is to bore a hole through the granite incasement at a level below the water surface, and that, substantially, is what is now being done for the third time.

By 1895 pumping had to be started in several of the shafts, the deepest of which was the Portland, 630 feet. From then on, water became an increasingly vexing problem. As greater depth was attained, pumping costs mounted both because of heavier flows and the continually increasing height to which the water had to be lifted. For the dual purpose of exploring the subsurface for veins and of endeavoring to circumvent high pumping heads by substituting horizontal working openings for vertical ones, four long tunnels were begun. In one of them, the Standard, so much water was struck in 1899 that it had to be abandoned when in 2,800 feet. Two years later a number of the mines were down to the ground-water level, as determined by the Standard Tunnel, and the question of providing deeper drainage arose. Up to that time the output was valued at $81,909,834, the camp having experienced its all-time banner year in 1900 with a yield of $18,199,736. The actual total return was probably several millions more, as ore stealers were very active.

In 1903, the El Paso Tunnel, the first of the bores intended primarily for drainage, was driven to connect with the El Paso Mine shaft. It was only ½ mile or so long and intersected the shaft at a point only about 550 feet below the collar. By 1905 the need for a deeper drainage structure was acute, and much discussion concerning one ensued. The outgrowth was the formation of the Cripple Creek Drainage Company by various mines, mills, smelters, and railroads whose continued existence depended upon finding some means of reducing or eliminating the huge pumping costs that were eating heavily into the profits of the mines. To finance the tunnel, the member organizations made initial subscriptions of more than $1,000,000, of which $860,000 came from the mine owners. D. W. Brunton of Denver, one of the foremost engineers of his day and inventor of the Brunton pocket transit that is known to mining men the world over, was engaged as technical advisor and established the line of the tunnel.

Work was started at a point on Cripple Creek in Gatch Park, several miles southeast of the mining area, on May 11, 1907. It was a gala occasion. Cripple Creek and its neighboring camp, Victor, put on holiday garb. Their populations turned out *en masse* and were swelled by nearly 2,000 visitors who arrived from Denver, Colorado Springs, and Pueblo in five special and two regular trains. Although all available conveyances were pressed into service, only 700 persons could be transported down the steep hills to the portal site where the ceremonies were to be held, so the others made merry in the towns while bands and drum corps entertained them.

The tunnel was named Roosevelt Tunnel, after President Theodore Roosevelt. It was started at Elevation 8,020, or 770 feet lower than the El Paso Tunnel, and its portal was 14,550 feet distant from its first objective, the El Paso Shaft. The contract to drive it was awarded to the El Paso Consolidated Gold Mining Company; but so little progress had been made by January, 1908, that it was canceled and a new one made with Albert E. Carlton, president of the First National Bank of Cripple Creek. His affiliation with this venture is of more than passing interest, for it is in honor of him and his brother, Leslie G. Carlton, that the new and deeper drainage tunnel now underway is named. More will be said of them later.

To accelerate operations, a shaft 685 feet deep was sunk to intercept the tunnel line at a point 7,975 feet from the portal. Headings were opened in both directions from the bottom of this shaft, and work was also carried on from the portal. In December, 1910, the gallery had been driven 15,740 feet and was in the breccia, having passed 1,190 feet beyond the El Paso Shaft. The flow of water was only about 100 gpm., so authority was given to extend the bore an additional 2,000 feet, or until a flow of 2,000 gpm. was encountered. This was done; but subsidence of the water level was still slow, and some of the mines that were remote from the tunnel did not benefit at all. Accordingly, further extensions were made in 1911, 1914, 1915, and 1916. The water table was thus gradually lowered, enabling some of the mines to deepen their shafts. On January 1, 1917, the tunnel was in 24,000 feet and the discharge at the portal was 8,500 gpm. This dropped to 4,000 gpm. by the end of the year, at which time the general water level in the district had been lowered 700 feet. In 1918 the Roosevelt Tunnel was completed, having reached a point on the Portland property 24,255 feet in from the portal, and on January 1, 1919, was finished a branch extending to the Port-

CHERRY PICKER

This vertical car-switching device has replaced the horizontally operating mechanism that was formerly used. The underground picture shows an empty car in elevated position while a train of loaded cars is passing beneath it. In this manner each car is, in turn, maneuvered to the head of the train and then moved up to the heading for loading. The additional headroom required for the transfer is blasted out at intervals of 100 to 200 feet. Above, the cherry picker is seen outside the tunnel. Mounted on top, at the near end, is the Ingersoll-Rand air hoist that provides power for operating it. Wire cables passing over sheave wheels at each upper corner of the frame have hooks on their ends, and these are attached to the lower corners of a car that is to be lifted.

land No. 2 Shaft, a distance of 2,131 feet.

The Roosevelt Tunnel is credited with having prolonged the lives of the deeper Cripple Creek mines by twenty or more years. It permitted the deepening of shafts; though some of the larger producers had workings below the tunnel level even before the bore was completed. This was true, for instance, of the Portland, whose No. 2 Shaft is the deepest in the district. It extends 3,037 feet into the ground, or to a point 906 feet below the connection with the drainage tunnel. The shafts of seven other mines, including the Cresson, Ajax, Golden Cycle, and Vindicator, also have penetrated the tunnel level. Most of them have been pumping water for many years, and the cost of this has made it more difficult each year to show mining profits, particularly as the average value of the ore has been decreasing steadily. To cite one example, the Golden Cycle Mine spent $83,400 in 1938 to pump water up to the drainage tunnel.

However, it is known that there is considerable paying ore left below the Roosevelt Tunnel level, and it is even possible that deeper explorations will uncover some of the fabulously rich accumulations that have been struck from time to time at higher levels. The greatest output has come from mines in the southern part of the crater, or in the adjoining granite, and they are the principal producers at present. Investigators of the U. S. Bureau of Mines have estimated that there remains in this area from $3,446,352 to $12,186,720 in recoverable ore. This appraisal takes no account, of course, of new ore bodies that might be discovered by deepening the shafts. These figures are regarded as conservative by the mining men of the district. Some diamond drilling has been done in the Cresson below the lowermost level (2,000 feet); but diamond drilling is not a reliable means of determining the presence of ore in Cripple Creek because of the "spottiness" of the deposits. However, it may be said that the ore from the 2,000-foot level in the Cresson was as good as that from any of the higher ones, and there is every reason to assume that the vein system continues downward. This would seem to be borne out by the experience of the Portland No. 2, where good ore was found in the lowermost workings which are 500 feet below the deepest Cresson workings.

There was talk of a new and lower drainage tunnel for many years; but it is doubtful if the cost of driving one could have been justified economically had it not been for the increase in the price of gold from $20.67 to $35 an ounce. In fact, it is this increase that has brought a fair measure of prosperity to Cripple Creek in recent years and restored it to its former position of Colorado's leading gold camp. Beginning in 1918, when the cost of labor and supplies soared, the output dropped almost without a break each year up to and including 1932, when it fell to $2,262,967, the lowest since 1894. By that time the district was reduced to only a shadow of its former opulence and was in a fair way to become a ghost camp.

Establishment of a higher price for gold in 1933 injected new life into Cripple Creek, and for the past several years production has been running around $5,000,000 annually. Last year between 1,500 and 1,600 men were regularly engaged in mining, and the population of the district was estimated at 4,500, or more than three times the number—1,427—counted in the 1930 census. With this stimulus, another tunnel was proposed. Some negotiations were carried on with a view to obtaining Federal funds; but, in the end, the principal operating company, The Golden Cycle Corporation, decided to finance the venture without assistance and set aside $1,000,000 for the purpose. This brings us back to further mention of the Carlton brothers.

Albert E. Carlton, a native of Illinois and a graduate of Beloit (Wis.) College, moved to Colorado in 1889, when 23 years old. He went to Cripple Creek in 1891, soon after the gold rush began, and took a job at $60 a month. He saved money, invested it wisely, and soon had enough capital to start the Colorado Trading & Transfer Company, a concern that later handled most of the coal, flour, and feed business of the district and also hauled much of the heavy machinery used in the mines. He next engaged in mining on a lease basis, and was successful.

Gradually, A. E. Carlton acquired interests in the Midland Terminal Railroad (now the sole survivor of the three rail lines that once served Cripple Creek), in the local reduction plants and power companies, and in banks in three Colorado cities. At 35, he was a self-made millionaire. He became president of the Golden Cycle Mining & Reduction Company (which today is The Golden Cycle Corporation). It runs the

Golden Cycle Mill near Colorado Springs, where all Cripple Creek ores are now treated, and owns several Cripple Creek mines and the Pikes Peak Fuel Company, operator of coal mines. He also headed the United Gold Mines Company, which operates several Cripple Creek mines. Another of his holdings was the Cresson Consolidated Gold Mining & Milling Company. (The Cresson has been the most profitable Cripple Creek mine for many years.)

Aside from these interests, A. E. Carlton organized and became the first president of the Holly Sugar Corporation, which operates ten beet-sugar factories in five western states. He was assisted in all these enterprises by his brother, Leslie G. Carlton, who took over the control of most of these far-flung activities when A. E. died in 1931. We have already seen that the latter played a leading part in driving the Roosevelt Tunnel, and he continued his interest in the matter of deeper drainage until his death. Leslie G. Carlton died in 1938, by which time plans for the new drainage gallery were pretty well formulated. He was succeeded as head of The Golden Cycle Corporation by Merrill E. Shoup, of Colorado Springs, son of a former Colorado governor and a man in whom the Carlton brothers placed great confidence.

TWO M.M.'S

Manager of mining and master mechanic. Alfred H. Bebee, vice-president of The Golden Cycle Corporation and general manager of all its mining operations, poses at the collar of the Cresson Mine Shaft with G.O. Rorabaugh, master mechanic for all the Golden Cycle mines. Mr. Bebee had much to do with the authorization of the Carlton Tunnel, and it is being driven under his direction. Mr. Rorabaugh helped design and construct much of the equipment being used in the tunnel. The drill carriage and the man car were both built by his forces at the Cresson Mine.

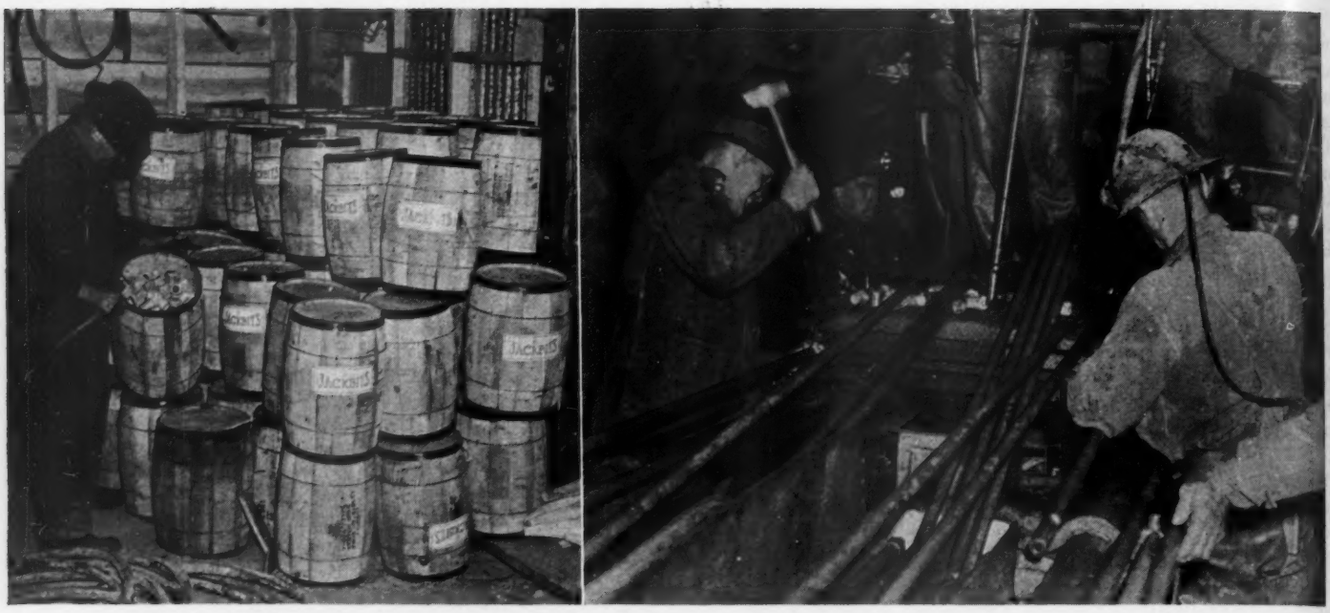
It fell to Mr. Shoup's lot to complete the final arrangements for the new bore, and it was only natural that it should be called the Carlton Tunnel as a memorial to the brothers. The Golden Cycle Corporation manifestly has a big stake in the benefits that will accrue from the tunnel. In addition to owning mines, its reduction mill depends almost entirely upon the Cripple Creek district for ores. Last year it treated 543,000 tons, of which 88 per cent came from Cripple Creek. However, it is equally true that all Cripple Creek mines will profit from the venture.

RECORD-DRILLING CREW

This group drove 27 feet in one 8-hour shift on April 6, when an advance of 74 feet was made in 24 hours. During the 31 consecutive days from March 10 to April 9, inclusive, the same crew contributed 681 feet of the 1,879-foot total by all shifts. The "shifter," L.A. Stiles, is holding a flashlight. The men are shown with the drill carriage at the heading.

In general charge of the Carlton Tunnel work is Vice-president Alfred H. Bebee of The Golden Cycle Corporation who is general manager of all mining operations of the Carlton interests in Cripple Creek. The tunnel, Mr. Bebee points out, is for the purpose of deep prospecting as well as drainage. It is known that there is not much mineralization outside the brecciated area, so there is little possibility of encountering ores of commercial value until the gallery has penetrated around 25,000 feet. No workable deposits were cut by the Roosevelt Tunnel. The flow of water is expected to be relatively small until the granite-breccia contact is reached.

The immediate objective is a point underneath the Portland No. 2 Shaft. *En route*, the bore will pass through the Ajax property. However, if the flow of water after the brecciated zone is tapped proves to be so large as to hamper operations, work in the tunnel will be suspended until the water table has been lowered by drainage. Thus, while the ultimate length of the main gallery is set at 32,000 feet, it may not be completed for several years. It is planned eventually to continue the tunnel to the Vindicator Mine and to drive a lateral to the Cresson property. Each of these supplementary bores would involve between 4,000 and 5,000 feet of additional tunneling, and the cost in both cases would be borne by the individual companies which belong to the Carlton group of mines. Mr. Bebee states that the lateral to the Cresson may be found to be unnecessary. In any event, it

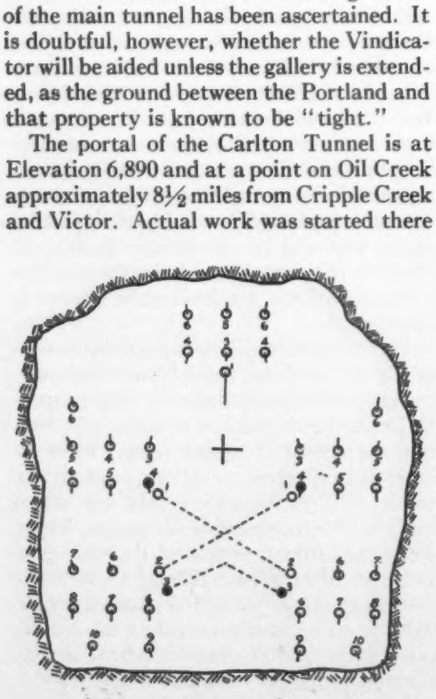


WHERE JACKBITS SAVE

After each round of drilling is completed, the drill carriage is moved back to the nearest siding, washed thoroughly, lubricated, and all air-line lubricators for the drills are filled. The supply of Jackbits and Jackrods for the next round is made ready, the various sizes of bits and lengths of rods being put in their allotted places, convenient of access. Thus, when the carriage goes back into the heading, everything is in readiness for drilling the next round. Each of the five drillers starts with a 3-foot rod and a 1¾-inch bit, and follows these, in order, with 5-, 7-, and 9-foot rods and progressively smaller bits. The rods are used over and over in the various holes, but bits are changed after each application. This is done on the carriage, immediately behind the drills, as illustrated at the right. The nipper at the left is striking a Jackbit with a soft-nosed hammer to loosen it from a rod, preparatory to replacing it with a sharp bit. Rods, with bits in place, may be seen in readiness for the drillers. In the left-hand picture is a part of a carload of Jackbits in stock in the reconditioning shop at the Cresson Mine. The bit used is a 4-point type, known as the Iron Bit, because it was developed for heavy drilling service in a Minnesota iron mine. It has buttressed wings that give it added strength. It will drill hard rock with little loss in gauge and is also designed to facilitate the removal of cuttings from the drill hole.

will not be driven until the drainage effect of the main tunnel has been ascertained. It is doubtful, however, whether the Vindicator will be aided unless the gallery is extended, as the ground between the Portland and that property is known to be "tight."

The portal of the Carlton Tunnel is at Elevation 6,890 and at a point on Oil Creek approximately 8½ miles from Cripple Creek and Victor. Actual work was started there on July 13, 1939. Dedication ceremonies were held on Labor Day, September 4, at which time Mrs. A. E. Carlton broke a bottle of champagne on the concrete retaining wall at the portal. No special trains were run into the district for the occasion; but several hundred residents of the section made the trip down the steep, winding 1-way road to the site. The bore is being advanced on a grade of 0.3 per cent, and will provide drainage to a depth approximately 1,140 feet lower than the Roosevelt Tunnel. It will be about 200 feet below the sump at the bottom of the Portland No. 2 Shaft.



TYPICAL DRILLING DIAGRAM

The open circles show the locations of the holes that are ordinarily drilled, while the solid ones indicate additional holes that are put in whenever the rock requires them. The figures show the order of firing the holes.

During July, 345 feet was driven and the first 336 feet was timbered. From that point on no supporting structure has been required, and it is not expected that any will be needed. The tunnel will not be lined with concrete, this being considered unnecessary. During August an advance of 1,201 feet was made, and since then, with the operations well organized, the pace has been quickened. In fact, since the work got well underway last September the daily progress has never dropped below 40 feet, which is believed to be something of a record in itself. Superintendent Austin, who has been engaged in tunnel driving for 25 years, attributes the speed to good organization of the crews and the sequence of operations, the employment of the best equipment obtainable, and the bonus system that is in effect. In addition to their base wages, the heading crews each draw extra compensation of $4 for each foot of progress in excess of 300 feet per month. This is prorated among the members according to their wages.

In cross section, the tunnel is 10 feet wide by 11 feet high. This was selected by Mr. Austin, who was merely instructed to drive a tunnel and was therefore free to choose the size that seemed to offer the best possibilities for speedy work. The section is roughly horseshoe shaped; but more material is taken out on the left side than on the right so as to carry the ventilation, compressed-air, and water lines on that side and still provide clearance for equipment running on the tracks. The floor is drilled and shot to a depth of 12 inches below final grade, but the muck is being left in place. This is to facilitate the laying of track, which is of 24-inch gauge and 45-pound rails.

As the heading is advanced, 6-foot sections of track are laid and welded to steel ties. If there is less than 6 feet of room, slide rails are used. These fit over rails already in position, overlapping them for several feet. After each 30-foot advance of the heading, standard 30-foot rails are laid on ties, and later, as time permits, the track is jacked up, 4x6-inch timbers are placed longitudinally under it, and it is brought to final construction grade. The track gang ordinarily works about 1,000 feet behind the heading. Water encountered is disposed of through ditches at the sides of the track.

HANDLING MUCK

Muck is loaded at the heading into rail cars (right) by an Eimco-Finlay No. 21 air-operated loader. An average of 34 cubic yards is handled each round. Storage-battery locomotives haul the 87-cubic-foot cars out to the dump (left), where they are tilted by a retractable roller arm that passes over the inclined frame shown.

These are made by cleaning out the 12-inch depth of muck and by nailing 3x12-inch timbers to the ends of the ties, providing drains approximately 2 feet wide and 18 inches deep.

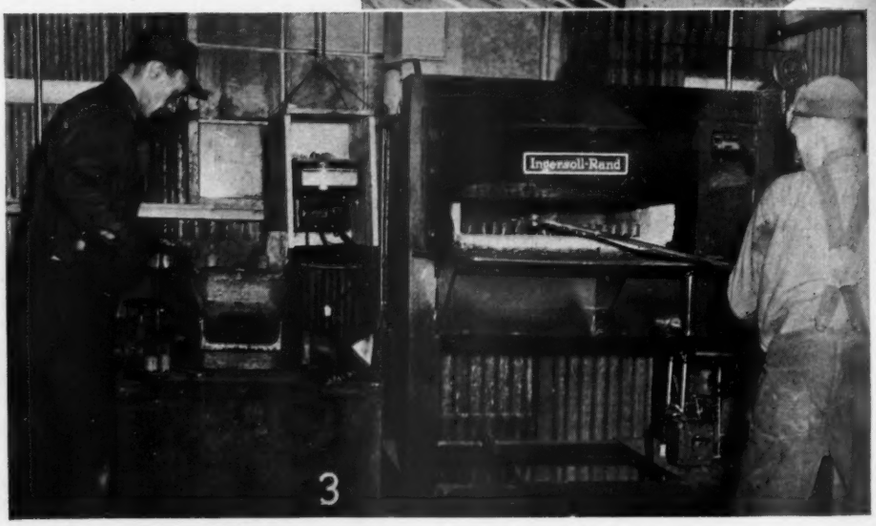
Drilling is done with a structural-steel carriage about 20 feet long and weighing 5 tons without drilling equipment. On the front of it are mounted five Ingersoll-Rand DA-35 drifter drills equipped with power feed. A similar drill is mounted at the rear and serves primarily for drilling holes in the roof to provide supports for a "cherry picker." An R-51 stopehamer is used to drill holes at the spring line on one side of the bore in which to place expansion pins to which are attached wires for holding the ventilation, air, and water lines. This drill and a spare drifter are carried in compartments on the sides of the carriage where they are available at all times. When the carriage is not in service, the column arms and drills are turned back, parallel to the tunnel line, and the drill mounted at the top front is lowered so that the unit can pass through the "cherry picker" that is employed to shift cars during the mucking operations.

An accompanying diagram shows the location of the drill holes. These make up a typical pyramidal pattern, and each machine puts in a group of holes within a relatively small area. From 37 to 42 ordinarily comprise a round, the latter number being used in particularly hard ground. So far the granite has varied from brittle to rather soft and spongy. Faster progress can be made in the former.

Drilling was started with conventional forged steel, and a changeover to detachable bits was made last September. Ingersoll-Rand Jackbits were adopted as standard equipment on March 26 after a trial period under regular service conditions. It was during the week following their introduction that the record progress of 488 feet was made. The daily totals for the week were: 68, 70, 69, 69, 70, 68, and 74 feet. At the outset of the work, starter steels of 2½-inch gauge were used. The size was later reduced to 2¼ inches, and then, when Jackbits were adopted, a further reduction was made to 1¾ inches. This has resulted in faster cutting and an

SUPERINTENDENT AUSTIN

The camera here caught "Long John" Austin swinging his 6-foot-8-inch frame along the tunnel track with ground-eating strides. Mr. Austin has spent 25 years in tunneling work. He started in the East, working in railroad bores in Kentucky, Virginia, Pennsylvania, and Maryland, and gradually absorbing the knowledge of rock and men that a successful tunnel driver must have. He first gained prominence as a superintendent in November, 1935, when crews under his direction drove the 1,000 Palms Tunnel No. 1 of the Metropolitan Aqueduct in California 1,101 feet in 26 working days. This performance broke all progress records on the aqueduct, and was believed to be the best rate of advance ever made in a bore that had to be supported with steel throughout. The daily report noted 45 feet of progress so often that the superintendent became known as "45-foot" Austin. From that job Mr. Austin went to the 13-mile-long San Jacinto Tunnel, longest of the aqueduct bores and considered to be one of the most difficult tunnels ever attempted. At the time, work was lagging because of excess water, bad ground, and labor troubles. He took over the Lawrence Adit, an intermediate inclined gallery excavated to provide an additional means of access to the tunnel line. Mr. Austin drove headings both ways from the bottom of the adit, and his crews met those from Cabazon Shaft on July 28, 1938. Another trouble job, this one in Colorado, next claimed Mr. Austin's attention. He was engaged by the City of Denver to complete its Jones Pass Tunnel through the Continental Divide to divert drinking water from the western slope. Numerous delays had previously slowed down progress, but he successfully concluded that bore and then signed on to drive the Carlton Tunnel. Present indications are that he will finish it in less than half the time originally set and at a lower cost than the owners estimated.



increase in drilling speed, which is proved by the fact that the drilling time per foot of advance from October on through March averaged 16.4 minutes, whereas in April it dropped to 13.5 minutes. The Jackbits are fastened to Jackrods of 1¼-inch hollow section. Holes are ordinarily drilled 9 feet deep, and four rods, having respective lengths of 3, 5, 7, and 9 feet, are used. With each change a bit of 1/16 inch smaller gauge is employed. The holes are thus bottomed at 1 9/16 inches.

The Jackbits are reconditioned by hot-milling them. To accomplish this, a complete shop has been set up at the Cresson Mine. It was located there because the expectations are that it will serve as a central shop for reconditioning the Jackbits used in the Carlton group of mines. Bits and rods are now transported to and from the tunnel by truck. The shop equipment consists of the following apparatus, all of Ingersoll-Rand manufacture: A JMA Jackmill, two Jackfurnaces with automatic temperature controls, and a bit-quenching fixture—all for treating bits. Also a No. 54 sharpener, two No. 500 air-operated cut-off wheels, a Toledo hand threader, a salt-drawing furnace, and brine and oil quenching tanks for treating Jackrods. Depending upon the progress in the tunnel, the number of bits reconditioned daily ranges from 1,000 to 1,300. These are being milled and hardened by two men during one shift. With no previous experience with a Jackmill, an operator was able, after two weeks at the machine, to mill 903 bits in five hours.

Following drilling, holes are loaded from the drill carriage with Du Pont Gelex No. 1 and with 65 per cent Hercules "Hercomite" and Hercules No. 6X electric-delay blasting caps. The carriage is then shifted back to a siding, 1,000 feet from the heading, and the round is fired from that point with current supplied by a storage-battery locomotive. The mucking crew starts back to the heading immediately, and the mucking machine and cars are moved up. Powder smoke, dust, and gas are withdrawn through an 18-inch steel pipe line, which is welded into 40-foot sections joined together by means of flanges that are sealed against leakage with rubber gaskets. Short, temporary lengths are used at the most advanced points to prevent damage to the permanently installed line during blasting. A blower, located at the portal and operated by a 90-hp. motor, is connected with this line and can exhaust air at the rate of 5,000 cfm. One booster blower is now set up inside the tunnel, and others will be provided as the system is extended.

All muck is wet down and then loaded with an Eimco-Finlay Model 21 loader. Three of these are on hand, and a spare is kept on a siding a few hundred feet back of the heading in case it should be needed. Muck is dumped into Granby steel cars with a capacity of 87 cubic feet. Switching of empty cars to the head of the train is accomplished with a portable "cherry picker" that lifts an empty car vertically by means of four cables so that a full one can be moved back underneath it. Power for the lifting is furnished by an Ingersoll-Rand air hoist. The steel frame is on skids and is pushed forward as required by a locomotive. Stations for its use are provided every 100 or 200 feet, the additional overhead room needed being obtained merely by drilling the holes at the top of the heading upward at these points. This "cherry picker" has replaced a laterally operating one and has saved some of the time that was required to "slab off" sidings. A lateral cherry picker was also used formerly for shunting the drill carriage out of the way, but the latter is now switched to a side-track by a locomotive. These larger sidings are shot out at intervals of around 1,000 feet. Muck is hauled to the portal in trains

4

5

6

RECONDITIONING JACKBITS AND JACKRODS

It has been proved that hot-milling is an economical and satisfactory method of reconditioning detachable bits wherever large quantities of them are handled, and it is being used in this instance. Bits are first sorted for size and next heated for about fifteen minutes in a Jackfurnace (1). With special tongs, the furnace tender places a hot bit on the locating fixture at the right of the hot-mill operator (2). The latter inserts the end of an arbor inside the threaded end of the bit and thus holds it while milling it in the Jackmill. First the cutting edges are milled by the edge of the cutter wheel, and then the bit is milled to gauge on the side of the wheel. The milled bits are reheated to the correct temperature in an automatically controlled Jackfurnace (3, right), and placed on a quenching fixture (3, left). There water is pumped up through screens on which the bits rest, the flow being controlled so that the skirt and threads receive less water than the cutting faces and, consequently, are not hardened so much. When the color of a bit indicates that the quench is sufficient, it is removed and put in boiling water. Bits treated in this way are restored to their original hardness for re-use. A Jackfurnace is also employed in connection with the heat treating of Jackrods (4). After being brought to the proper temperature, threaded ends are quenched and drawn in suitable solutions to impart the exact degree of hardness desired. Shank ends are heated, then forged by a No.54 sharpener (5) and reheated for quenching in oil. Bar steel and Jackrods are quickly cut to desired lengths by a No.500 air-operated cut-off wheel (6). R.W. Welch, master mechanic at the tunnel, is demonstrating how it is used.

of ten or more cars. There the train is divided and the cars are run out five or six at a time for dumping.

Structures at the portal include an office, compressor house, and a change room for the men that is equipped with shower baths. The compressor house contains two Ingersoll-Rand compressors, a direct-connected, electric-driven Class PRE and a belt-driven unit. They have a combined piston displacement of approximately 1,800 cfm. A feature of the job is the relatively high air pressure that is used. The gauge pressure in the compressor house is 132 pounds, and the air reaches the drilling machines at around 125 pounds. It is conveyed into the tunnel through a 6-inch steel pipe line that is welded into 60-foot lengths outside the portal. The sections are assembled by means of flanged joints, and additional units can be installed in twelve minutes each. The air line runs along one side of the tunnel below the ventilating line. Water for the drills is pumped to the heading through a 2-inch pipe, being picked up from the drainage that flows out of the bore.

Work is carried on 24 hours a day, seven days a week, and so far the only shutdown has been on December 25 and 26 of last year. The day shift is made up of 28 men, the swing shift of 22, and the night shift of seventeen. The night shift has one shift boss, one mucking-machine operator, five drillers, five drillers' helpers, one steel nipper, two motormen, one compressor operator, and one man at the dump. In addition to these, the swing shift has one track boss and four track workers. The day shift has the foregoing, plus one additional track worker, one superintendent, one master mechanic, two mechanics, one office man, one engineer, three blacksmiths, one electrician, one truck driver, three inside pipe men, and one powder man.

The summary of operations during April shows that 213.91 rounds were drilled and blasted for a total advance of 1,696 feet. The average advance per round was 7.95 feet, and the average number of rounds per day was 7.13. The average drilling time per foot of advance was 13½ minutes, and the average mucking time twelve minutes. A total of 57,250 pounds of powder was used, or 33.8 pounds per foot of advance.

The monthly progress, in feet, has been: July, 345; August, 1,201; September, 1,367; October, 1,534; November, 1,474; December, 1,387; January, 1,438; February, 1,518; March, 1,735; April, 1,696. The average daily progress has, accordingly, been 46.7 feet. Excluding the work during July, when timbering had to be done, the average daily advance has been 48.7 feet. On May 18, the heading was 14,570 feet in from the portal.

The operating personnel is: John R. Austin, superintendent; L. Stiles, A. Stiles, and E. Gardner, shift bosses; R. W. Welch, master mechanic; and J. G. Farmer, engineer.

GENERAL VIEW OF PLANT FROM HARBOR

Making Gas the Modern Way

George R. Steere*

IN THE 150 years that manufactured gas has been produced and distributed for purposes of illumination, cooking, heating, etc., it has been made either by distillation of the volatile, combustible substances found in bituminous coal or by some form of the Lowe process which was first introduced in 1875. As students of gas manufacture know, the distillation of bituminous coal to obtain gas would be highly uneconomical if the latter were the only consideration. But as coke is a valuable by-product, this method has been and probably will continue to be used to an extent determined directly by the need for coke. Actually, gas so made occupies the place of a by-product, according to present-day standards. The Lowe process, however, lends itself to a much more complete utilization of the raw material. Its application is not limited to bituminous coal: it can be employed to manufacture gas from anthracite and coke, as well.

*Assistant Manager, The Portland Gas Light Company.

While other gases have been made and used for industrial purposes at the points of production, carbureted blue gas made with modern machines constitutes a large proportion of the gases manufactured for general distribution. The basic operation in making blue gas in a water-gas plant is described in all textbooks of high-school chemistry. It involves the burning of coal or coke in a closed retort or generator under a blast of air, which rapidly raises the temperature of the fuel to incandescent heat. The air supply is then shut off and steam is blown through the heated mass. At that temperature the steam is decomposed, its oxygen combining with the hot carbon to form carbon monoxide, together with a small quantity of carbon dioxide, and liberating hydrogen in the free state. This reaction takes place at a temperature in the neighborhood of 2,000°F., and with the absorption of heat. As the temperature drops, the reaction is altered, and the carbon-dioxide content of the gas is increased proportionately, so that 3 or 4 per cent of it is always present in the finished product. As carbon dioxide lowers the calorific value of the gas, it is important that the temperature in the closed retort be raised again. This necessitates an alternating cycle of operations, involving, first, blowing with air to bring the fuel bed to incandescence, and, second, injection of steam to make gas.

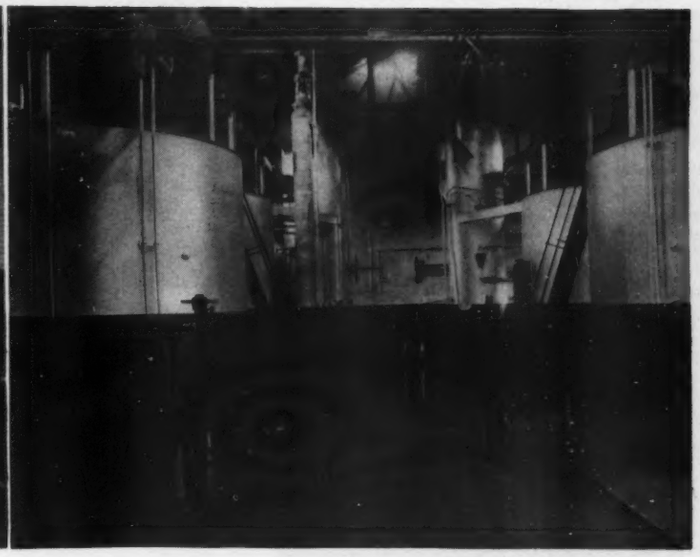
In practice, the cycle is commonly of four minutes' duration, and this is divided into approximately 1½ minutes of heating and a 2½-minute period of gas production. If this were the end of the process, the result would be a gas containing about 300

COAL-HANDLING SYSTEM

Coal or Coke is unloaded from cars into underground pockets to the right of the buildings shown in the picture at the left, and is then elevated to the bin in the center without the use of labor. This equipment was installed last summer by the Beaumont Birch Company. From the overhead hopper the fuel flows to the gas machines by gravity.

GAS MACHINES

Two Lowe process machines of the latest type were installed in 1938 and now carry the entire load of the system. They are designed to utilize low-grade coal and oil with high efficiency and make it possible for the company to take full advantage of fluctuations in prices of raw materials. The picture just below was taken on the operating floor. The bottom view shows the operating controls.



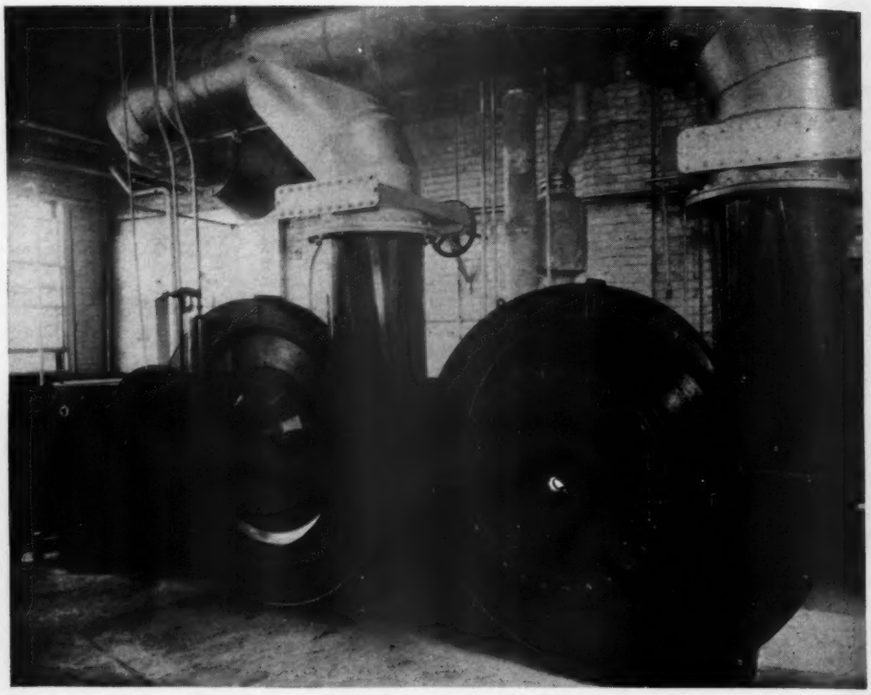
Btu's per cubic foot. This would be uneconomical on two counts. Not only would much of the heat of combustion during blowing be lost, but a gas with a calorific value of 300 Btu's is of too low a grade for profitable distribution. Pipes in delivery lines and burners would have to be increased in size, as compared with those used for gas with the common minimum standard of 500 to 550 Btu's per cubic foot.

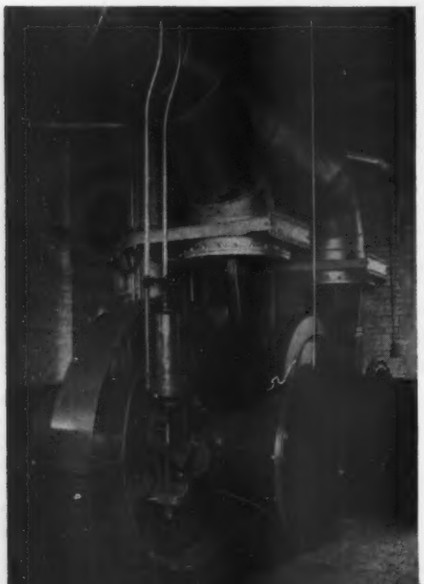
These disadvantages have been overcome by allowing the hot blast gases escaping from the generator during the blowing period to flow through connecting chambers—a superheater and a carburetor—before exhausting them to the atmosphere. These chambers are filled with firebrick, arranged checkerwise, which absorbs much of the heat from the blast gases that would otherwise be wasted. When the proper heat balance has been established between the fuel bed and the brickwork, the air supply is shut off and steam is introduced beneath the grate. The resultant gas is then enriched by passing it through the chambers into which oil is sprayed and cracked by the stored heat, thus carbureting the blue gas and converting it into a permanent product rich in hydrocarbons—the increase in Btu's or calorific value depending upon the quantity of oil used. Not all the hydrocarbon compounds produced during the cracking process are absorbed by the gas. The remaining fractions are condensed and form what is known as tar, which constitutes the only valuable by-product of the Lowe process.

From the foregoing it will be apparent that the equipment used to furnish the air has to operate under exacting conditions. Not only should the air be introduced at full blast so that no time is lost between the end of the gas-making period and the reheating of the fuel bed, but it is equally necessary that the supply be shut off the instant the fuel bed reaches the temperature suitable for generating gas. Because

BLOWERS

These machines supply the air for blowing the fuel to incandescence, after which steam is introduced for the gas-making run. These operations are alternated, and a cycle ordinarily takes about four minutes. The blowers are Ingersoll-Rand Type FS units, each with a rated output of 19,000 cfm. of air at 42 inches of water pressure. One is driven by a steam turbine and the other by a 150-hp. constant-speed motor. Blowing continues for approximately 1½ minutes. As the interval between blowing periods is only about 2½ minutes, it is not practicable to shut the machines down. Power consumption of the turbine-driven unit is reduced during the idling period by throttling the steam valve. In the case of the motor-driven unit, a blast gate is closed. The control mechanism for doing this is shown on the near unit in the view below. To avoid objectionable noise that results from shutting off the discharge, this blast gate has been placed on the blower intake.





blowing and gas production are each of such short duration, it is not practicable to shut down the blower—in fact, some manufacturers have found that it is desirable with certain fuels to blow for from 10 to 15 seconds while gas making is in progress.

Because of these requirements, centrifugal blowers are now generally used to supply the air. Constant-speed motor-driven units lend themselves well to this service, for their power consumption is approximately proportional to the volume of air delivered. At shut-off (zero volume) little power is used. The flow of air can, of course, be controlled either at the intake or the discharge of the blower. Previous practice favored the location of a hydraulically operated gate at the blower discharge adjacent to the generator, for with the gate closed the blower continues at full speed and consumes little power. In addition, full pressure is available on the blower side of the gate to start the blast of air through the generator immediately upon opening the gate.

The advantages of this arrangement are offset by one drawback in the case of plants located in residential districts. When the blower is operating with the discharge shut off and with the intake open to the atmosphere, it makes an objectionable noise. This difficulty has been surmounted by blower manufacturers working in conjunction with gas producers. Today, the blast gate is installed at the intake of the motor-driven blower, and, in addition, there is the usual blast valve on the generator intake. While this arrangement results in some sacrifice in quick-blast effect, the loss in pressure is almost negligible with the modern type of blower. As the fire cannot utilize the same amount of air at first as it can when it becomes hotter, this initial lower pressure is really an advantage. Moreover, the noise is prevented, and it takes less power to drive the unit.

In the case of blowers operated by steam turbines, it is customary to lower the steam pressure and to shut off the blower simultaneously. This reduces its speed to a satisfactory idling point, usually to from 500-1,000 rpm. When the gas-generating period is over, the steam valve opens immediately, and the blower is brought up to full-load speed for the blast. By this method all noise is eliminated both during the run, as the gas-making period is termed, and during the blow, when the gate is open.

From 1850 to January, 1939, Portland, Me., has been manufacturing gas for general distribution by the distillation of coal, and is a typical example of the development the industry has undergone in that period. During these 89 years, The Portland Gas Light Company has used three different types of equipment. In 1898, carbureted-blue-gas machines were added to the plant to meet customer demands, and in 1938, two units of the most modern design for the production of gas by the Lowe process were installed. These machines were built to burn either low-grade fuels or oils. At the same time was purchased the latest and best available associate equipment for supplying fuel, steam, oil, and air, together with apparatus for the removal and processing of the by-product, tar. The results that have been obtained with the new plant since it was put in operation have amply justified the care that was taken in selecting the machinery.

As the work of installation progressed, more and more of the old equipment was put out of service, and on January 26, 1939, the load was being carried entirely by the new or third system by which The Portland Gas Light Company has generated gas for industrial and domestic consumption. The outstanding feature of the plant, as compared with the earlier ones, is that it uses lower-grade fuels and oils with greater efficiency and with a minimum of labor. This makes it possible to take the fullest advantage of fluctuations in the prices of the raw materials.

The coke or coal is delivered at the yard in bottom-dump cars, and is discharged into an underground storage bin from which it is elevated to an overhead hopper, whence it feeds to the gas machines by gravity. The blowers used are of the Ingersoll-Rand type. One of them is driven by steam and the other by a 150-hp., 2,200-volt motor. The latter blower has a built-in hydraulically operated butterfly valve on the inlet nozzle. As the unit is in action a little more than a minute in every four, it does not

pay to shut it down between blows, and the inlet valve, together with an impeller of special design, serves to prevent the terrific surge that would otherwise be induced in the blower and discharge line while it is not delivering air. The objectionable noise attending this surge is therefore eliminated, and the power consumption during the idling period is considerably reduced. It is estimated that the built-in blast gate has resulted in a power saving of approximately $1,400 in a year. The steam-driven unit does not require such a valve because it is throttled to low speed while idle.

The two gas machines have a combined capacity of 7,000,000 cubic feet of gas daily and, like the coal-handling system, are automatically operated. They, as well as the equipment for conditioning the gas and the tar, were installed by The Semet-Solvay Engineering Company, which also directed the necessary building changes, etc. Another problem to be solved was that of insufficient gas storage. The company's largest gas holder, which is located across the city from the plant, has a capacity of 1,500,000 cubic feet, and since it was constructed, more than twenty years ago, the load has increased to a point where it did not throw enough pressure except with the top lift raised—that is, when fully extended. This meant that it had an available storage of only 500,000 cubic feet.

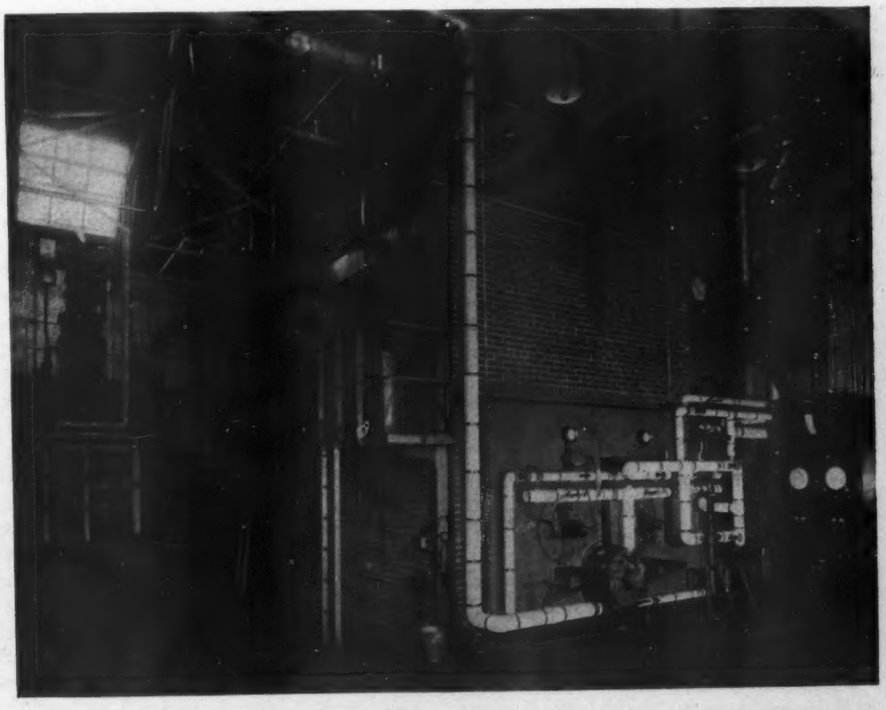
The holder is of the telescoping type, which, briefly, is a cylindrical structure made up of a number of sections or lifts moving in guide frames and surmounting a tank filled with water. Each lift is smaller than the one beneath it, and has a channel cup or trough at the lower edge that fits into an inverted channel cup or dip at the top edge of the adjoining section. As gas is admitted, and the lifts rise successively out of the tank, the troughs fill with water and engage the dips, thus sealing the joints, making them gastight. It is obvious that the entire weight of such a holder is exerted on the gas only when it is raised to its full height. As the gas is discharged, the pressure on it is decreased approximately one-half or one-third, depending on whether it is a 2- or a 3-lift structure, as each section comes to rest on the bottom of the tank and its weight is transferred to the ground.

Last year The Portland Gas Light Company installed an automatic booster station to build up pressure in the line. It is run by a variable-speed motor, which begins to operate as soon as the lower lift lands and at sufficient speed to compensate for the weight of that lift. This is accomplished through the medium of an inclined mercury column that is affected by the drop in pressure at the inlet of the booster and serves to close a low-voltage contactor circuit which, in turn, closes the high-voltage starting equipment—the desired speed being assured through suitable resistance. When the intermediate lift touches bottom, the further decrease in pressure throws in another contactor, lessening the resistance and increasing the motor's rate of speed with the result that the outlet pressure remains constant.

To recharge the holder, this procedure is reversed and the booster shut down when the third or top lift is again in the raised position. The gas is admitted by means of an inlet pipe which passes through the bottom of the tank and extends to a height about 6 inches above the water level. A similar pipe serves as an outlet for the gas. The only unusual features of the booster station are that no governor is required to maintain constant outlet pressure on the main and that it uses no power other than that needed to compensate for the weight of the lifts.

In the past it has been necessary to keep up steam in two coal-fired boilers, with a fireman on duty at all times during the cold season, to prevent freezing of the water in the channel cups and the tank of the gas holder. Now, in keeping with the generating plant, the holder has an automatic heating system consisting of a suction line which reaches from a point 6 feet below the surface of the tank to the inlet of either of two Cameron pumps, an electric- and a gas-engine-driven unit. Water is thus delivered to a Patterson Kelly heat exchanger from which it goes to a manifold, on the holder frame, that feeds a total of fourteen jets—four near the bottom of the tank, four at the water level, and three spaced at equidistant points circumferentially in each of the two cups. Steam is supplied to the heat exchanger by two automatically controlled gas-fired boilers each of 53 hp. These are large enough so that one serves as a spare, except in extreme weather when both are used. The condensate is returned to the boilers by gravity. The auxiliary water-circulating pump is operated by a direct-connected Waukesha engine which is equipped with a generator storage battery and starter and uses gas from the holder as fuel.

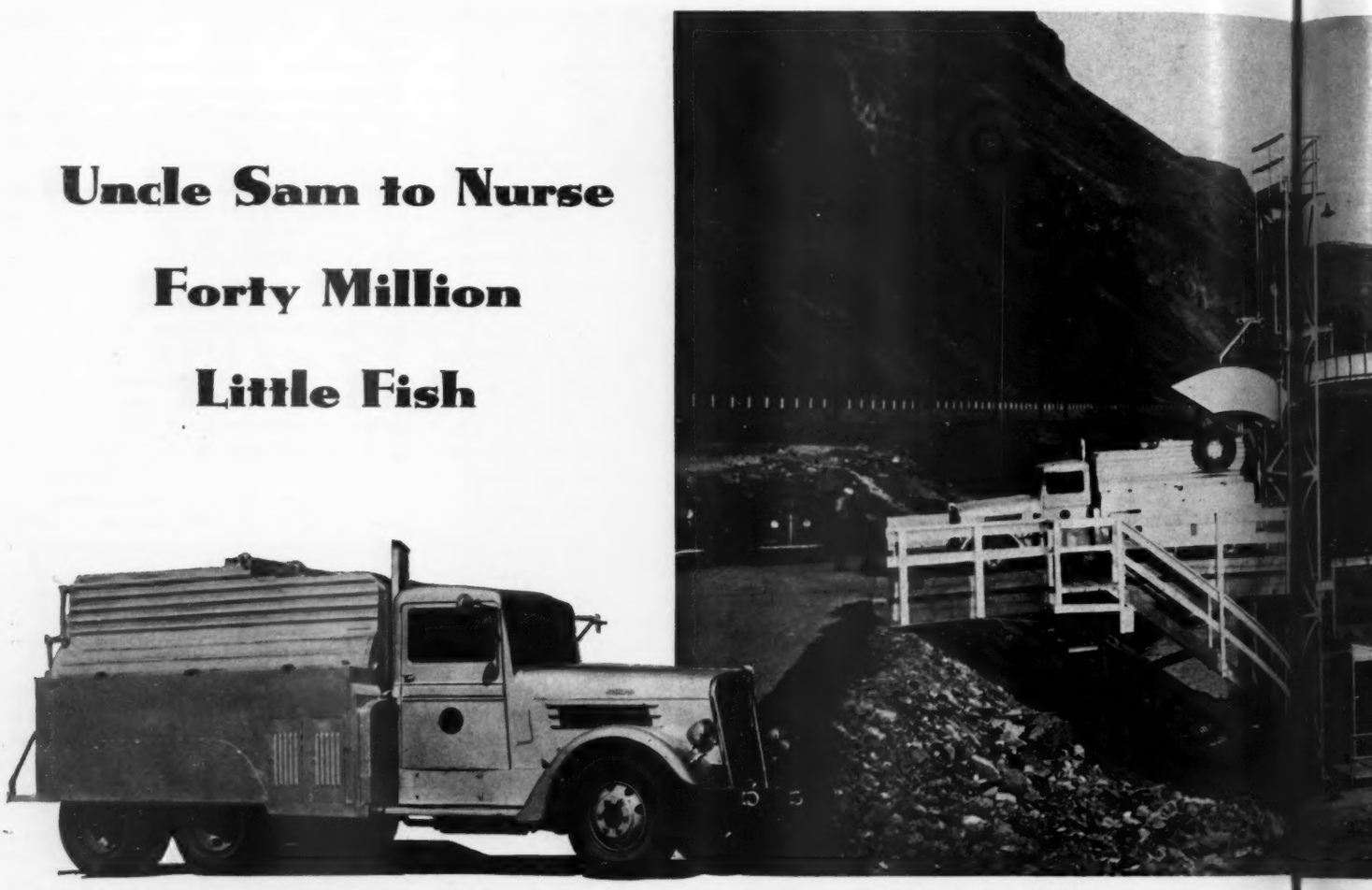
Control of the heating system is effected by a number of thermostats. One of these is located on the cold side of the holder. It sets the water-circulating pump going when the temperature of the air drops to 33°F., and stops it when the temperature has risen above that point. Another is in the top channel cup, and this starts the gas-fired boiler at 34° and shuts it down at 37°. Still another is in the water line ahead of the pump, and this one starts the boiler if the temperature of the water coming from the holder is below 32°. In this way the circulating water is heated enough to prevent it from freezing in case of power failure and until the gas-engine-driven pump can be put in use. As a further precautionary measure, a second thermostat has been placed in the top channel cup, and this closes a battery circuit that rings an alarm in an employee's house near the holder should the water in that cup reach a temperature of 32°. In addition, the bell is so connected in the circuit that it rings when the pressure of the gas drops below normal by reason of "low holder" and power failure. The battery which supplies the energy to sound the alarm is the same one that serves the Waukesha motor of the auxiliary pump. The heating system and the booster have so far given highly satisfactory service.



NEW BOILER

This is a Babcock & Wilcox, Stirling-type, 415-hp. unit with full automatic Bailey control equipment. The picture was taken while the boiler was under full load.

Uncle Sam to Nurse Forty Million Little Fish



ARTIFICIALLY conditioning the medium in which man lives—air—has become a commonplace. But large-scale conditioning of the medium in which fish live is something of a novelty, and this the U.S. Bureau of Reclamation has undertaken to do for about 35,000 adult salmon and steelhead trout and for several million of their offspring. To that end it has driven a 2,500-foot tunnel through a spur of the Cascade Mountains and thus tapped Snow Lake at a point 150 feet below its surface. The object is to make the cold water of that deep mountain lake available in late summer for maintaining suitable low temperatures in the holding ponds and the fish hatchery which the Bureau now has under construction at Leavenworth, Wash., as a means of perpetuating the breeding of migratory fish in the tributaries of the upper Columbia.

Because the Grand Coulee Dam will be so high that salmon, bound upstream to spawn, might find it difficult or impossible to ascend any fish ladder that could be built around it at a reasonable cost, and, in any case, because young fish coming downstream might be destroyed in the tremendous waterfall over the finished dam or in the turbines in the power plant, the Bureau of Reclamation is carrying out the greatest single fish-conservation scheme that has so far been undertaken.

No other feature of the Columbia Basin Project has engaged wider popular interest, and none is perhaps so generally misunderstood. Many factors are involved, as the survival of the fishing industry on the Columbia is not wholly nor even largely dependent on the Grand Coulee Dam. Three important varieties of fish—chinook, blueback salmon, and steelhead trout—migrate from the sea to their breeding grounds in the headwaters of tributaries of that river. The fish do not all perform according to a perfectly uniform time schedule, neither do they multiply in direct ratio to the run in any year. Their general habits are fairly well known; but their future behavior cannot be forecast with mechanical precision. The salmon spawn in the fall and end their life cycle, while the steelheads, after spending the winter in the streams, return to the ocean in several cycles.

Chinook, or king salmon, appear in the upper river from May to October. The spring run spawns in late summer, and the summer and fall runs in October—the young Chinook emerging from the gravel in February or March the following year to begin their journey to the sea. The single run of bluebacks lasts approximately six weeks, starting about the middle of July. Bluebacks frequent only streams with lakes in their courses to serve as rearing ponds for the young the year after their birth. They begin their migration to salt water the second spring and normally go back to their breeding grounds when four years old. Some salmon develop precociously, and return to spawn in less than the usual period. Steelheads travel upstream in two runs: in spring, when the fish breed soon after they reach the headwaters, and in fall. The latter run remains there throughout the winter and spawns in the spring.

A mysterious instinct which is almost, not quite, infallible, enables a salmon after maturing at sea to find its way back to the stream in which its very early life was spent. Whatever spot might have been the birthplace of its ancestors, and regardless of where it might have been hatched, the mature salmon will return in the spawning season to the waters in which it got its early free growth. Consequently, a tribe of salmon can be transplanted to a given stream by compelling its adults to breed there, or by planting fertilized eggs or young fish there.

The first count of fish ascending the Columbia is made at the Bonneville Dam after commercial fishing has taken its uncounted toll at sea and in the 146 miles of the river below the dam. The total number going upstream, and, no doubt, the proportionate distribution in tributaries above the Coulee Dam, have varied from year to year. According to one report of the Federal Bureau of Fisheries, 4 per cent of the Chinook, 13 per cent of the blueback salmon, and 1 per cent of the steelhead trout

Photo, U. S. Bureau of Reclamation

FISH ELEVATOR AND TRUCK

One of the fish traps and elevators at Rock Island Dam, where salmon and steelhead trout will be taken from the Columbia River and transported to a huge hatchery near Leavenworth, Wash., 40 miles away. A truck is shown in position to receive a load of fish. At the left is a close-up of one of the special 1,000-gallon tank trucks, which include facilities for chilling the water while the fish are en route to their new home. The rear four wheels are double-tired, there are air brakes on all the wheels, and the 5-speed transmission is provided with an overdrive that permits the vehicles to be run as fast as 50 miles an hour.

that passed Bonneville reached the Grand Coulee.

It is true that about 28 per cent of the Columbia watershed is above the Grand Coulee. But the region is remote from the sea; and it seems to be the natural tendency of migratory fish to be more numerous in the lower than in the upper tributaries, depending on the extent to which the headwaters of the streams remain accessible. The drainage area above the Grand Coulee Dam spawns less than 5 per cent as many salmon per square mile as does that below the Bonneville Dam. Even so, the loss of the spawning grounds above the great Grand Coulee is a serious matter, and a substitute for them is to be provided.

As a result of extensive studies made by the Federal Bureau of Fisheries, the Washington State Department of Fisheries, and the Bureau of Reclamation, there has been devised a plan that will not only preserve the upper Columbia salmon run but actually increase it. New homes are to be found for the dispossessed fish in tributaries of the Columbia that rise on the east slope of the Cascades and enter the main stream between the Grand Coulee Dam and the Rock Island Dam, 150 miles below it. These rivers—the Wenatchee, Entiat, Methow, and Okanogan—formerly bred large crops of salmon; but now the runs are small by reason of obstructing dams without adequate fish ladders, and irrigation projects with unscreened diversion ditches. These conditions have been corrected.

Under an agreement with the Puget Sound Power & Light Company, the Bureau of Reclamation has provided the three ladders in the Rock Island Dam with holding pools, traps, and elevators by means of which the fish are caught, sorted, and delivered to specially built tank trucks that haul them away. There are eight of these trucks, and they were designed by the Bureau of Reclamation. Each carries a 1,000-gallon fish tank; a compartment forward of the tank large enough to stow 1,200 pounds of crushed ice; and on each side a 125-gallon, motor-driven, centrifugal pump, one serving as a spare. Water from the top of the tank is drawn through coils in the ice bunker and returned to the tank, being diffused over the bottom. By means of a thermometer on the instrument board and a throttle in the water line, the driver can control the temperature of the water, gradually reducing it *en route* from that of the river at Rock Island to that of the water at the destination. Air is introduced into the circulating water by an injector to maintain the necessary supply of oxygen. There is a sliding hatch cover on top for loading the fish, and a quick-opening door at the rear for dumping them.

Other facilities not having been completed in 1939, the adult fish were dumped in the streams, the bluebacks only in those with lakes in their courses—the Wenatchee and the Okanogan. Trips varied in distance from 50 miles—requiring about six hours for icing, loading, hauling, and dumping—to 155 miles to Osoyoos Lake on the Okanogan River and at the Canadian border. It took sixteen hours to make that circuit. During 1939, the eight trucks traveled more than 102,000 miles; and the ice used per trip ranged from 500 pounds in cool weather and on short hauls to 2,000 pounds on long hauls in midsummer.

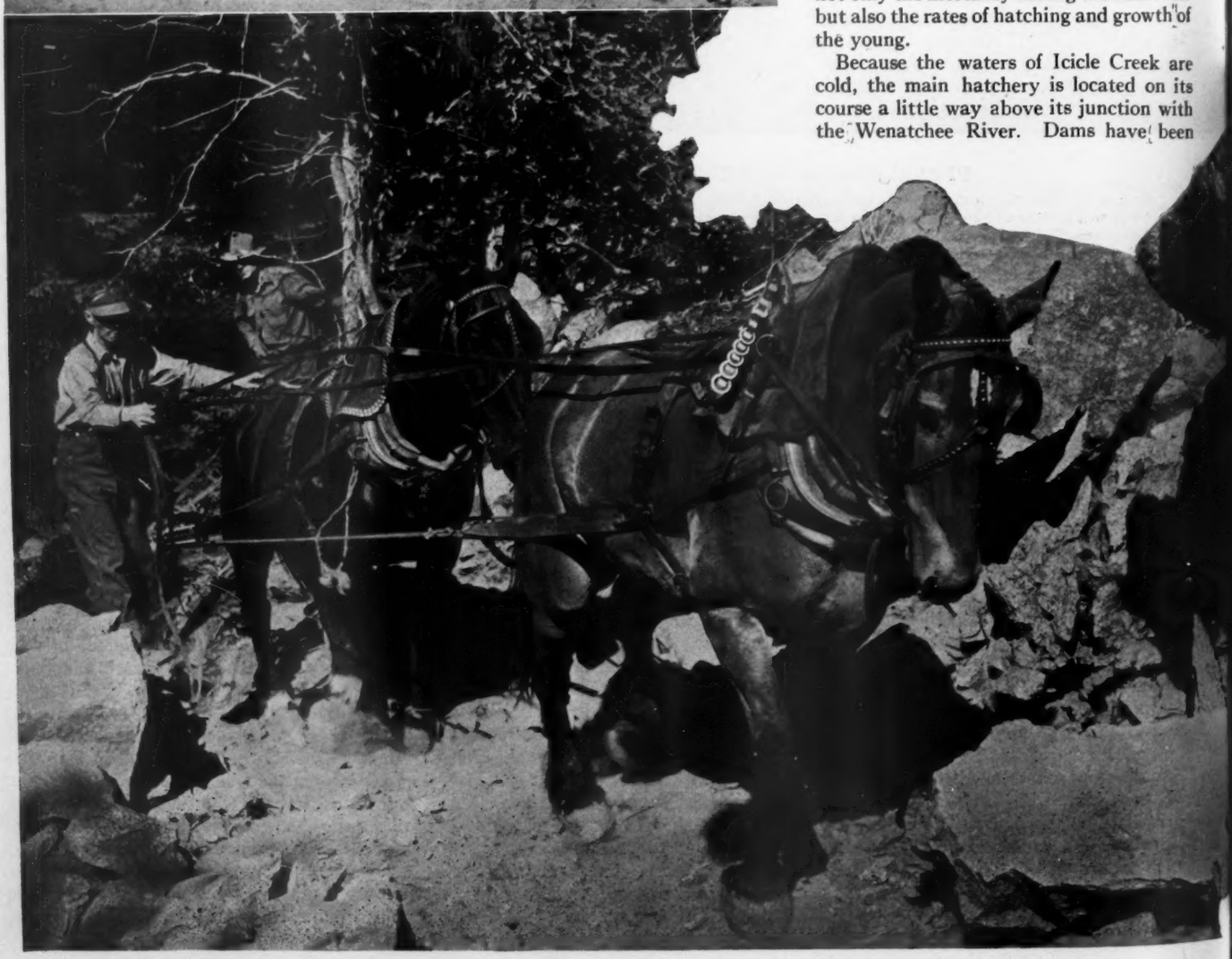
Beginning with the 1940 season, all adult fish will be transported to a new mammoth fish hatchery on Icicle Creek, near Leavenworth, about 40 miles from the traps. There they are to be held in artificial ponds from one to six months, or until they ripen for spawning. Eggs will be distributed later to sub-hatcheries on the several streams. After three to five months in the hatcheries, depending on the temperature, the fry will be transferred to rearing ponds.

Fish, like many other forms of wild life, are remarkable for fecundity and mortality. Tests indicate that Chinooks each yield 3,600 to 6,800 eggs, averaging 4,900; blue-

backs, 1,800 to 6,200 eggs, averaging 2,700; and steelheads, 2,800 to 8,300, averaging 5,300. It is estimated that 40,000,000 to 100,000,000 eggs could be taken annually at Leavenworth. If released when hatched, about 95 per cent of the young bluebacks perish on their voyage to the sea; if reared three months, less than 80 per cent are lost; and if allowed to remain nine months, less than half die. Feeding the young fish in rearing ponds is a matter of great labor and expense. If cared for until such ages and in such numbers as recommended by the state fisheries department, the young will consume not only all the carcasses of the spawned fish but around 100 tons of purchased food. After three months to a year in the rearing ponds, the young fish will be distributed by means of the tank trucks and dumped at various points into the several streams to remain until their seaward migration begins.

Providing a lying-in home for 30,000 to 40,000 fish, and boarding schools for a thousand times as many young fish, is a monumental undertaking. Not the least of the designers' problems was that of insuring an adequate supply of water at required low temperatures, for temperatures affect not only the mortality among the adult fish but also the rates of hatching and growth of the young.

Because the waters of Icicle Creek are cold, the main hatchery is located on its course a little way above its junction with the Wenatchee River. Dams have been



built across the natural channel of the creek and these form holding ponds for the fish. There are also two diversion canals: one to carry water from Icicle Creek to the hatchery, and the second, which is 3 miles long, to make the waters of the Wenatchee River available.

Late in the summer, the flow in Icicle Creek is greatly reduced owing to the diminishing run-off from its watershed and to the upstream diversion of irrigating water. At the same time, Wenatchee River is relatively warm, so additional cold water will very likely be necessary. A potential source of 12,000 acre-feet of cold water was found in deep, 111-acre Snow Lake, which lies about 8 miles distant high in the Cascades and on a tributary of the Icicle. However, this supply could be obtained only by tapping the lake 150 feet below its surface, and so a 2,500-foot tunnel was driven from an adjoining watershed. The water released from this conduit, under control of a tube valve, will flow into Nada Lake, thence into Icicle Creek, and from there to the holding ponds and hatchery.

Access to the site from which the tunnel was to be driven presented a serious problem, for it is in high rugged mountains and 6 miles away from the nearest road or trail; and the job was to be done in winter. Bids on transportation of equipment, supplies, and materials by airplane and by pack trains were considered. One pilot proposed to land an amphibian plane on Nada Lake: another proposed to drop his cargoes by parachutes to be furnished by the Government, which was to assume the risks of breakage. The job was awarded to J. G. Barnett, of Okanogan, who, with 50 to 100 horses, carried in nearly 500,000 pounds of food, camp equipment, engines, gasoline, air compressors, drills, steel, powder, and tools. Under a contract with the Bureau, the Forest Service built 6 miles of 30-inch trail, beginning about the middle of September, 1938, and finishing on November 3. Packing began on October 17.

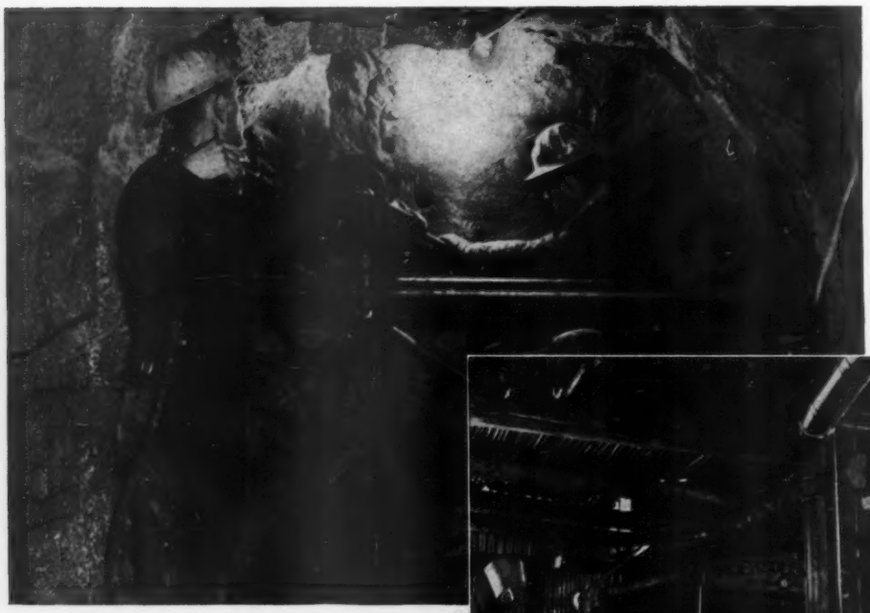
The camp, on Nada Lake, consisted of a mess hall, cook shack, dormitories, compressor house, blacksmith shop, powder house, and other facilities to accommodate the force of 25 to 30 men that spent the winter there. A short-wave radio set maintained contact with the field office at Leavenworth. In order to avoid the delay that would have been occasioned by advertising for bids, awarding the contract, and getting the camp established before cold weather set in, the tunnel was driven by Government forces, the actual work of excavating beginning late in November, 1938, on a 3-shift schedule.

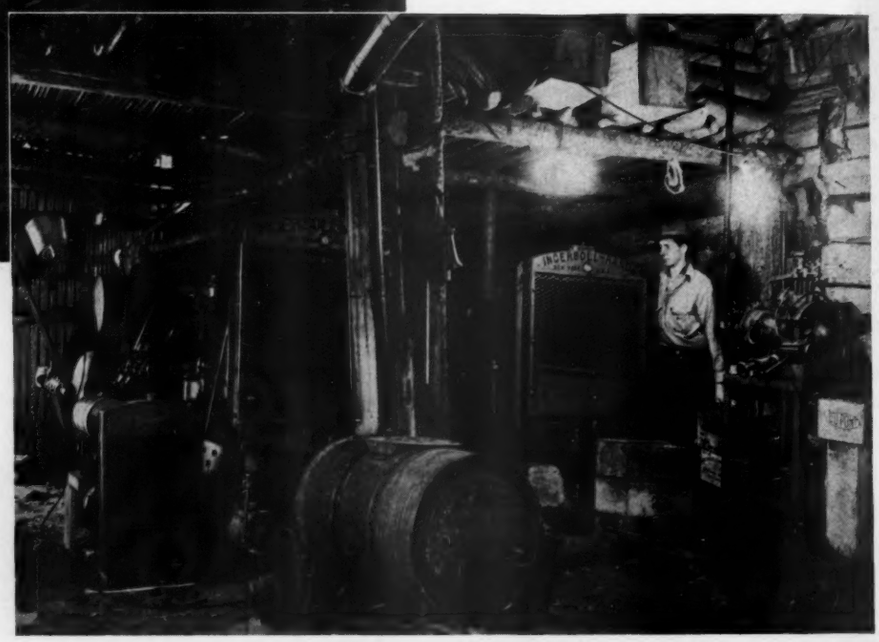
The 5x7-foot bore penetrates hard, dense granite. It was started about 200 feet below the surface level of Snow Lake and was driven 2,500 feet on a 1 per cent grade through the ridge separating the drainage basins of Nada and Snow lakes. Beginning at a point about 40 feet from the portal, and for a distance of approximately 1,000 feet, the tunnel passed through granite nearly free of seams. Thereafter, a dry fault and some water-bearing formations were encountered, but none failed to drain quickly, proving that there was no connection with the lake. The last 300 feet was driven under the lake in dry, hard rock.

The tunnel was excavated to full section by drilling an average of 23 holes 5 feet into the face and loading about 100 pounds of 40 per cent and 60 per cent gelatine dynamite per round. Five electric delays were ordinarily used, each shot yielding approximately 6 cubic yards of broken rock and advancing the heading about 4¼ feet.

TAKING IN EQUIPMENT

Nada Lake, the base of operations, is in a rugged section and 6 miles from the nearest road. To get the half-million pounds of equipment required for the job to this point, the Forest Service built a 30-inch trail over which the supplies were freighted. Lighter materials were packed in on horses, while heavier articles were hauled by two or more horses, hitched in file because of the narrowness of the path. The camp at Nada Lake is shown above. It was from this location that a 2,500-foot tunnel was driven to tap the bottom of Snow Lake. The work was done during the winter, and this camp was established to house the equipment and to accommodate 25 to 30 men. A short-wave radio set maintained contact with the field office at Leavenworth. Excavating began late in November, 1938, and the last round was fired October 14, 1939.





TUNNEL HEADING AND COMPRESSOR PLANT

The 5x7-foot bore through granite was driven with three DA-35 drifters and an R-51 Stopehamer. Compressed air was furnished by the two portable compressors shown below. Note the drill rods on the rafters overhead. Jackbits proved to be convenient and economical in the remote setting, and they were sharpened on the grinder seen at the right-hand edge of the picture.

Compressed air was furnished by two Ingersoll-Rand gasoline-driven compressors of 210- and 315-cfm. capacity, and three DA-35 drifters and one R-51 Stopehamer were employed. The advantages in such a remote locality of Jackbits—detachable bits—and of a bit grinder to resharpen them are obvious.

Soundings made through the ice in the vicinity of the projected upper terminus of the tunnel showed that the lake bottom sloped about 1:1.7 and was covered with 2 to 3½ feet of mud. The intention was to drive the final section diagonally upward from the heading and normal to the lake bottom; but feeler holes, drilled from the end of the 1 per cent section, led to the belief that a boulder lay over the proposed opening into the lake and would probably choke the tunnel after the final shot.

At a point about 15 feet back from the face a sump was sunk below the tunnel floor to receive the shattered rock from the last blast, and directly over it an inclined raise was driven to within 7 feet of the lake bottom, the raise being reduced in cross section as it was advanced. After drilling holes for the final shot, the crew retreated, digging four additional sumps at intervals along the tunnel floor to catch such material as might be swept past those ahead by the first rush of oncoming water.

The soundness of the rock through which the tunnel passes justified using it as a pressure tunnel and placing control valves near the lower portal. A concrete bulkhead, approximately 7 feet thick and keyed into the massive granite, was located about 150 feet from the portal, and from it a 30-inch steel pipe was carried about 30 feet down the tunnel to an emergency gate valve, followed by a tube valve to control the rate of flow. Access to the valves was provided by driving an adit diagonally above and parallel to the tunnel to a control chamber over the valves.

With the steel pipe and gate valve in position, the 32 holes at the face were loaded with 220 pounds of 60 per cent gelatine dynamite. A small charge was permissible, because it was not intended to throw the broken rock into the lake; and high-strength dynamite was used for the purpose of shattering the rock to avoid choking the opening. "No-delay" and four different delay, ventless, electric blasting caps were utilized; and, as a precaution against failure of some cap to explode because of moisture, an auxiliary circuit of Cordeau interconnected all holes of like delay. The several Cordeau circuits were connected to an independent firing circuit through delay caps corresponding to those of the holes they interconnected. Leading wires for the two circuits were passed through a 2-inch pressure-gauge pipe in the bulkhead and were so suspended inside of it that the wire ends would be automatically drawn in when cut off after firing.

Owing to trouble in the circuit near the face, the firing of the last round on October 14, 1939, was delayed several hours and occurred after dark so that no observations of surface disturbances on the lake could be made. With the gate valve shut, several seconds elapsed after throwing the switch before any sound was heard at the bulkhead and a rush of air from the 2-inch pressure-gauge pipe was observed. With that pipe closed, a pressure of 86 pounds developed within a minute. Subsequently, it fell to 75 pounds, then rose to and remained at 80. Water filled the tunnel within three minutes. There is some doubt as to whether the dynamite charges exploded in the planned sequence or simultaneously; but tests have shown that there will be an adequate flow of water from Snow Lake and that the Government's finny wards at Leavenworth will bask in cool water in the hottest summer weather.

The driving of the tunnel was under the direction of Charles F. Lybecker, superintendent, and the late G. A. Warning, resident engineer. Work on the Columbia Basin Reclamation Project, one of the conservation enterprises of the U.S. Department of the Interior, is in charge of Frank A. Banks, supervising engineer for the Bureau of Reclamation of which John C. Page is Commissioner and R. F. Walter chief engineer. The operation of the migratory-fish conservation program on the upper Columbia is in charge of the Federal Bureau of Fisheries. A game fish hatchery, to be provided by the Bureau of Reclamation, will be operated by the Washington State Department of Fisheries for the purpose of stocking the 151-mile reservoir above the Grand Coulee Dam.

Men and Oxen Transport Compressor

C. R. King

ON THE TRAIL

The larger pieces such as the engine, cylinders, crankcase, and base each constituted a separate load for a cart. The heaviest one was the engine, and it was placed on a 4-wheeled conveyance pulled by twelve oxen. The other carts had two wheels, and each was drawn by four oxen. On steep grades, all the animals were hitched in turn to each cart. Note the construction of the vehicles. They are built of green timber, which permits making new parts en route by cutting down trees. Smaller pieces of the compressor, that were mostly too unwieldy to be transported on mule back, were lashed to poles and carried by Indians.

PRIMITIVE transportation methods were recently resorted to for freighting a compressor to a gold and silver mine near Monterde, Mexico, that is owned by the Cia Minera Guazapares, S.A. The machine is an Ingersoll-Rand Model 425 semi-portable driven by an oil engine and weighing approximately 14,500 pounds. It was originally in service at a mine at Sabinal, Mexico, from which point it was moved to Monterde under the direction of the writer, manager of the aforementioned mining company. Four types of haulage were employed during the shipment: railroad, truck, ox teams, and human carriers.

The compressor was carried from Sabinal to Creel, via Chihuahua City, by rail. Creel is the present terminus of the railroad, and from that point on it was necessary to utilize other facilities. There is a truck road—that is, a road that can be negotiated by trucks during good weather—for about 25 miles from Creel. From the end of this road to the mine, a distance of 35 miles, primitive haulage methods were used. In order to divide the load, the machine was partially dismantled for this final stage of the journey. The low-pressure cylinder and the high-pressure cylinder were each placed on a 2-wheeled cart. Three 4-wheeled carts were employed for the engine, the structural-steel base, and the compressor crankcase or gear case.

The engine was the heaviest of the loads, and was drawn by twelve oxen. Each of the other carts was hauled by four oxen making the total number of draft animals required 28. About fifteen men were needed to handle them and to look after the material on the carts. The remaining parts of the machine, consisting of radiators, sections of housing, etc., were packed by Indians because, in most instances, they were too unwieldy to be transported by mule. The heavier ones were lashed to poles to permit two or more men to carry them. About 30 Indians toted these miscellaneous parts.

Creel is on the eastern side of the Continental Divide, and Monterde and the mine are on the western side. The truck road crosses the divide on a railroad grade that will some day be completed and provide rail connection between the west coast and Chihuahua. In fact, some work on it is now being done. Creel is at an elevation of 7,692 feet, and the mine at about 7,500 feet. The highest altitude reached by the truck road is around 8,000 feet, although some of the surrounding peaks are approximately 10,000 feet above sea level.

Twelve days were required to make the trip from the end of the truck road to the mine. On steeper than ordinary grades the carts were handled in relays—that is, all the oxen were hitched to one cart at a time. Even so, there were many grades where even the combined efforts of the animals were not sufficient to keep a cart moving, and these were negotiated with the aid of a logging winch.

The wheels of the ox carts are made of green pine and the axles of green oak, a self-lubricating combination that can be heard for 3 miles! Ordinarily, the axles are good for about 100 miles, but the wheels for only about 10 miles. Whenever a wheel wore out, a halt was made, a tree cut down, and a new one fashioned and put in place on the spot.

A few years ago, when the writer had to transport some heavy machinery to the mine, he had several steel carts made up in El Paso at a cost of $80 each and shipped to rail head. He thought that they would be more satisfactory than the primitive wooden ones in general use; but this did not prove to be the case. The rough terrain and rocky trails soon caused damage to the steel conveyances that could not be repaired. A wooden cart, such as those illustrated, costs only five or six pesos and can be fixed without difficulty when it breaks down.

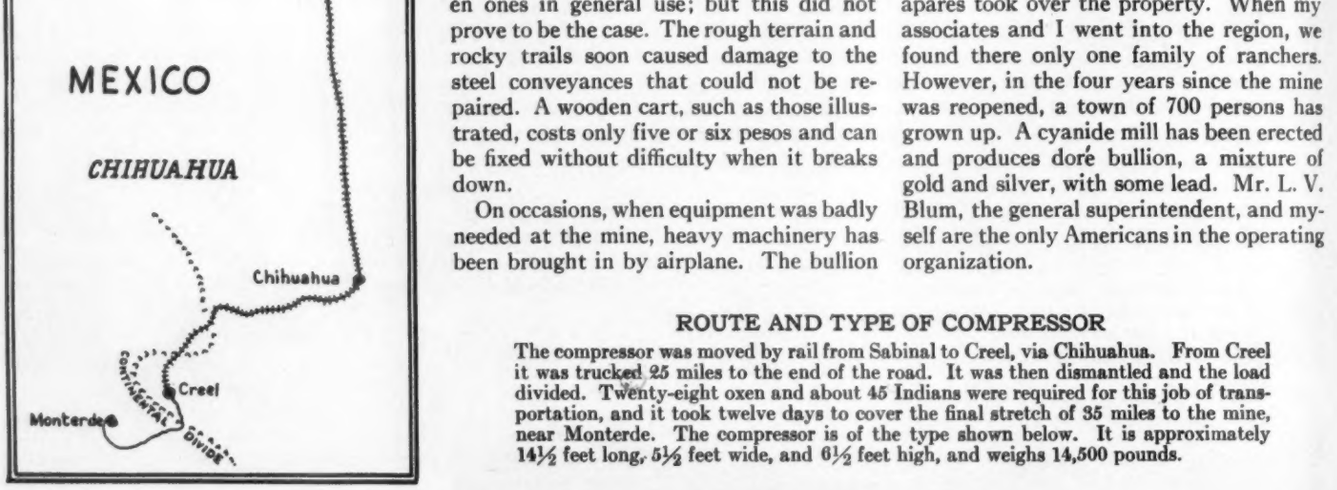
On occasions, when equipment was badly needed at the mine, heavy machinery has been brought in by airplane. The bullion and payroll also are usually flown between Chihuahua and the mine. The flying time is 1½ hours, whereas the 150-mile train trip from Chihuahua to Creel takes sixteen hours and the remainder of the trip several days, the number varying with the method of transportation.

The mine produces gold and silver. It was first operated by Spaniards, who were forced to abandon it during the Indian revolt in 1760. The workings lay idle until Mexico became a republic, after which it yielded ore that had an estimated value of from $500,000 to $750,000. The output, all of which came from near the surface, made four Mexican families comparatively wealthy.

In 1902 an American concern bought the property and did considerable development work by hand methods, but produced no ore. Those activities were brought to an end by the revolution of 1910. Thereafter, the mine and the surrounding area were deserted until 1936, when Cia Minera Guazapares took over the property. When my associates and I went into the region, we found there only one family of ranchers. However, in the four years since the mine was reopened, a town of 700 persons has grown up. A cyanide mill has been erected and produces doré bullion, a mixture of gold and silver, with some lead. Mr. L. V. Blum, the general superintendent, and myself are the only Americans in the operating organization.

ROUTE AND TYPE OF COMPRESSOR

The compressor was moved by rail from Sabinal to Creel, via Chihuahua. From Creel it was trucked 25 miles to the end of the road. It was then dismantled and the load divided. Twenty-eight oxen and about 45 Indians were required for this job of transportation, and it took twelve days to cover the final stretch of 35 miles to the mine, near Monterde. The compressor is of the type shown below. It is approximately 14½ feet long, 5½ feet wide, and 6½ feet high, and weighs 14,500 pounds.



ATOMIC ENERGY

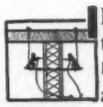
PROGRESS in smashing atoms has reached a point where predictions are being made that atomic energy will be available for industrial use within twenty years. This prophecy is prompted by the recent isolation of U-235 in experiments at Columbia University and the University of Minnesota. U-235 is an isolotope of the metal uranium, an isotope being a form of an element that contains two or more varieties of atoms.

When the first work of smashing atoms was done, it was believed that atomic energy would never be of commercial value because the amount of energy released was less than that required to release it. This was true even when samples of uranium containing U-235 were subjected to experiments, the explanation now given being that other isotopic forms of uranium that were present blanketed the energy released by U-235. However, when the latter isotope was isolated and tested, it was revealed that it could readily be smashed and that it produced a power yield 5,000,000 times as great as that derived from burning coal.

The principal obstacle in the way of harnessing atomic energy on a commercial scale is said to be the present difficulty of isolating U-235. At least 300 scientists are reported to be working on the problem, and eventual solution is taken for granted. The isotope is present in uranium oxide in the proportion of 1 part in 139, and uranium oxide is being produced at the rate of 1,000 tons a year. While the scientists are searching for their answer, it is held to be entirely possible that they may discover isotopes of cheaper, more abundant metals such as iron or lead that have high energy-releasing properties and that will be easier to separate from their ores.

A new atom-smasher that is more powerful than any hitherto available is now being built at the University of California with $1,150,000 given by the Rockefeller Foundation, and important results along the line just mentioned are expected from it. The principle on which atomic power is founded, and which has been demonstrated, is that when some atoms are smashed they form other atoms of smaller weight and the difference between the two comes off as energy. It is too early to envision just how atomic energy is going to be applied to the ordinary power-consuming jobs of industry, but that will be solved in time.

CRIPPLE CREEK



IF IT had not been for the Carlton brothers, Albert E. and Leslie G., Cripple Creek, Colo., might almost be a forgotten gold camp. When the lean years came to the once world-famous mineralized area that lies just back of Pikes Peak, mines that had produced millions were forced, one by one, to give up the ghost. But the Carltons took them over and kept them going. Now, even though the Carltons are dead, their influence promises to keep Cripple Creek alive for many years to come. For the Carlton Tunnel, now being driven 6 miles to remove the water that has thwarted profitable deep mining, will be a veritable open sesame to additional rich ore.

Cripple Creek was doing well until the United States entered the World War. Then, mounting prices of powder and other essential supplies and scarcity of labor increased production costs so much that profits dwindled. Meanwhile, the better mines, which were the deeper ones, were being forced to spend more and more money to pump water.

The Carltons, however, had faith in Cripple Creek, and they showed it by lending money to many of the operating companies to keep them going. But, even with this help, some of them couldn't survive, so they became parts of the Carlton domain. The Carltons had money to advance because they had not put all their eggs in one basket. In addition to their mine holdings, they had investments in railroads, banks, an ore-reduction mill, and a beet-sugar company. But their mill, their railroads, and some of their banks depended largely for their success upon the continuing production of Cripple Creek ores. By lending the mines money, then, they were promoting or protecting their own interests; but none can deny that it takes courage to pour cash into losing ventures. It was fortunate, of course, that the price of gold was increased beginning with 1933, but the Carltons could not foresee that action.

Both the Carltons have passed on, but their spirit lives after them. Governmental agencies were approached with regard to financing the Carlton Tunnel, but they declined. Whereupon those whom the Carltons had chosen to carry on their interests appropriated, without much ado, $1,000,000 to drive the bore and started work without delay. How fast the tunnel is going forward is told elsewhere in this issue.

In addition to the Carlton Tunnel, there is further evidence in Cripple Creek at this time that the spirit that actuates mining men does not die with them. On Tenderfoot Hill, in the northern part of the extinct volcano in which the gold-bearing veins are found, the Tenderfoot Mining Company is carrying on exploratory operations through the Mollie Kathleen Shaft. The president of the company is Mrs. Verner Z. Reed, widow of a man who made a fortune in Cripple Creek in years gone by. Mrs. Reed is financing the operations because of an abiding affection for the camp in which she lived for many years and also because she is convinced that paying ore will be found with increasing depth.

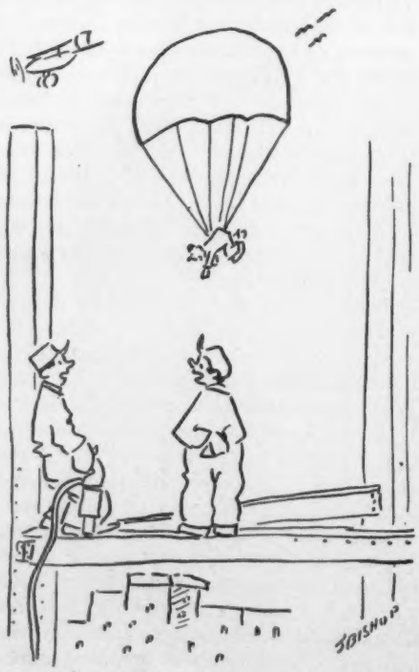
The northern part of the crater did not produce rich ore near the surface during the early days of the camp, and consequently was not given much attention later on. With greater depth, however, the Mollie Kathleen has uncovered the telluride ores that are typical of the southern part of the crater and has also encountered silver and lead. The latter mineral is not present elsewhere in the district. These discoveries have led to the theory that a zone of enrichment will be found at a depth of 2,000 to 2,500 feet under Tenderfoot Hill. If this should be borne out, a large area that was believed to be barren will become productive and Cripple Creek will, indeed, be given a new lease on life.

Industrial Notes

A respirator of exceptional lightness that offers protection from dust, pollen, and certain bacteria has been announced by the American Optical Company. It weighs only 1½ ounces, and is said to exclude particles as small as a micron—1/25,000 inch.

To prevent the formation of sludge in oil storage tanks and the possible fouling of oil lines, fuel systems, and oil burners, the Wil-Co-Lene Chemical Company is offering a solvent that is said to keep heating surfaces clean and tanks free of rust- and sludge-forming moisture. One gallon is sufficient to treat 4,000 gallons of Bunker C, or 6,000-7,000 gallons of light oil.

The Blaw-Knox Company for its Power Piping Division has recently published a book that meets a long-felt need for a method by which flexibility analyses of piping can be quickly and accurately obtained. The work is entitled *Design of Piping for Flexibility with Flex-Anal Charts*, and represents more than ten years of effort on the part of E. A. Wert and S. Smith of The Detroit Edison Company. It was prepared with the idea of placing into the hands of the experienced piping engineer a series of charts and simple formulas that would enable him to determine the stresses, forces, moments, and deflections in piping designs of 1-, 2-, and 3-plane structures in much less time than it would be possible for him to do with the accustomed methods. The new and improved curves and formulas developed by the authors can be read more easily and closely and reduce the amount of arithmetical work without affecting the accuracy of the solutions. Furthermore, there are curves and formulas that are applicable to shapes of pipe structures not considered in previous books on the subject. The work is a valuable contribution to the art and is available without charge to executives, engineers, and others interested in the problems of pipe design provided the request for it is addressed to the Blaw-Knox Company, 1525 Pennsylvania Avenue, Pittsburgh, Pa., on their business letterheads. For others it is priced $3.00. It is handsomely bound in a stiff cover; and, in addition to 44 pages of text and tables and 36 pages of charts, it has numerous illustrations showing piping in process of fabrication and completed jobs.

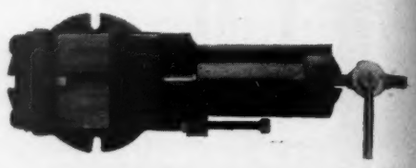


"Look at that crazy fool. Boy that must take nerve!"

The Texas Company has recently announced that it is producing a new lubricating oil—Texaco 303 Motor Oil—especially for automotive diesel and gasoline engines designed for heavy-duty service. It is claimed that the lubricant overcomes one of the major difficulties experienced with engines of this type—that is, the clogging of filters, screens, and oil lines, and has made a record in this respect with several of the country's leading bus and truck fleets. According to Texaco, it has been definitely proved that the oil will not break down under prevailing high speeds, temperatures, and pressures; that it assures far cleaner engines than is normally the case; and that it maintains greater efficiency over long periods of continuous operation without harmful sludge and carbon deposits. It is being made available as quickly as possible throughout the United States.

One of the technical developments of the Anthracite Industries Fellowship at the Mellon Institute in Pittsburgh, Pa., is the production of mineral wool from anthracite colliery refuse and anthracite ashes. Mineral wool has many industrial and domestic applications, because it is one of the best available heat-insulating materials and is also a fire retardant and proof against vermin and decay. The process has been demonstrated on a semiplant scale with colliery refuse. Ashes need special treatment before use and therefore have not yet been subjected to large-scale tests; but the mineral matter in both is similar in character and chemical composition. Broadly, the waste material is mixed with limestone and burned in a special furnace to produce white mineral wool of good quality.

A new vise for general machine-shop and tool-room equipment is being offered by the Larkin Air Vise Company of Portland, Conn. Clamping and release are effected by means of a pneumatic cylinder which, it is claimed, makes it possible to save a surprising amount of time in handling material, especially when operations are short and many pieces are manufactured from one set-up. It is suitable for milling, shaping, planing, and bench and drill-press work, and comes in five sizes with jaws ranging from 4 to 8 inches in width and 2¼ to 3½ inches in depth. The units vary in over-all length from 16 to 25¼ inches and



require air at from 50 to 100 pounds pressure per square inch. The vise is regularly equipped with plain, tool-steel jaws and a hand-controlled air valve; but it can be obtained with special jaws, a foot-operated valve, a universal base, and other features.

At the U. S. Forest Products Laboratory there is emerging from the experimental stage a process by which all kinds of wood waste can be converted into plastics, according to a recent issue of *Science and Appliance*. Lignin, the constituent that holds the cellulose particles together and produces the woody structure, is really a plastic. It is water resistant but brittle, and needs a filler to give it strength and bulk. The filler is easily provided by leaving enough of the cellulose material in sawdust when it goes to the digesters. Plasticizers, such as aniline and furfural, are added to the mass, which is then molded into any desired form, large or small, at a pressure of 3,000 to 4,000 pounds per square inch and a temperature of 302°F. The product is black and shiny and will take a paint or metal-powder finish or veneer. It can be easily machined, and is said to be a good insulator.

Delivering coal by pipe line like oil is a subject that crops up recurrently. The latest news is that the Standard Oil Company of Ohio holds a patent on a system invented by Dr. Robert E. Burk, professor of chemistry at Western Reserve University, Cleveland, Ohio. By it the coal is ground fine at the colliery and mixed with water containing certain chemicals in which it is carried in suspension. It is believed that any kind of coal treated in this manner can be pumped through pipe lines to central points of distribution, where the solids can be separated from the solution in a few minutes, it is claimed. According to Doctor Burke, "The saving on this process will increase with the distance, because the cost of the chemicals, processing, and the amount of water are fixed. There is no evident reason why it should not be an economic success; and it would be the means of opening up coal deposits that are now inaccessible."